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History in the Making.

When in the course of human events an ideal is made a reality, history is being made. The opening of the Chemists' Building in New York is a milestone in the history of chemistry in America. In its stately simplicity and dignity it is a monument to the idealism of its builders. In its equipment and facilities it is a great endowment for future service. This ideal was realized without outside help through the combined efforts of American chemists. A few years ago the question might have been raised whether American chemists could do it. They could, they would, they did. And future historians will speak of the opening of the Chemists' Building as the beginning of a new epoch in the history of chemistry in America.

This was the first step—and it is always the first step that counts. Next year an International Congress of Applied Chemistry will meet for the first time on American soil. The American organization has been perfected and tentative rules have been formulated, which will be found on page 173 of this issue. We gladly place our correspondence columns at the disposal of our readers for critical discussion. For all agree that next year's Congress must be made a grand success, worthy of America and American chemistry.

Smelting Fine Ore.

One of the great sources of loss in the smelting of base metals, particularly copper, is the escape of fine ore in the reduction process. It is frequently the case that the fine ore is of high grade and then the loss becomes more serious and the ingenuity of the metallurgist is taxed to provide a suitable remedy. Naturally, in all preliminary treatment, such as concentration, every effort is made to produce as coarse a product as possible and to avoid the production of fine concentrate, but when the mineral is finely disseminated through a large amount of gangue and occurs in small crystal masses, fine grinding and concentrating become a necessity. Then arises the problem of the best disposition of the fine ore.

Various solutions have been proposed, and some adopted. In one instance the fine concentrate is mixed with concentrator slime and furnace flue dust and briquetted. The briquettes are sufficiently strong to stand the subsequent handling and are used as part of the blast-furnace charge. This scheme offers quite a satisfactory method of disposing of these three troublesome products, although the quantity of slime which can be used is not commensurate with that produced.

Another suggestion that has been made and practiced to a limited extent is to mingle the fine ore with low-grade matte or rich copper slag, in such quantity as will be absorbed, with or without solidification of the absorbing medium. This process gives a semi-fused mass suitable for smelting if slag

has been used, or for converting in the case of matte. In either event the fine ore shortly becomes part of a molten bath with no chance for escape as dust.

The most recent and novel of the means proposed is to be used at Cananea for avoiding loss in the treatment of Miami copper concentrate. This material is very fine and high grade. Ordinary methods of smelting would result in high losses and hence some scheme had to be adopted to increase metallurgical recovery. It is proposed to blow the fine concentrate trough the tuyères directly into converters charged with matte and thus cause it to become a part of the molten bath. This will eliminate dust loss and will lower the smelting cost materially.

Expenditures at the Gary Steel Plant.

Four months ago we made some editorial remarks upon "the iron industry's insatiate thirst for capital," and the annual report of the United States Steel Corporation gives figures of its expenditures at its new plant at Gary, Ind., which furnish a concrete illustration of the principle adverted to. The expenditures at Gary would make the iron and steel engineer of half a generation ago stand aghast. To Jan. 1, 1911, they amounted to $69,978,695, of which $16,072.851 was spent in 1910. For work authorized at Gary, but still to be completed, there was the additional sum of $15,500,000, making in round figures a total of $85,000,000 expended, or to be expended, at Gary in connection with the present plans. This expenditure covers the land for both the plant and the town (less credits for lands, lots and houses sold), buildings and other town improvements, an enormous amount of terminal railroad work, as well as the moving of two trunk-line railways, lake harbor and docks, by-product coke ovens, 12 blast furnaces, 42 open-hearth steel furnaces and various rolling and finishing equipment.

There has been appropriated from surplus net income a total of $65,000,000 for Gary, of which $10,000,000 was appropriated in 1910; in addition to this construction work aggregating $9,775,506 was financed by three subsidiary companies, the American Sheet & Tin Plate Company, the American Bridge Company and the Chicago, Lake Shore & Eastern Railway Company, which have been doing construction work at Gary. Thus there is left, of the $85,000,000 expenditure authorized, a trifle over $10,000,000 to be provided, either by future appropriations from surplus earnings, or by subsidiary company financing.

The production of the Gary plant in 1910 was as follows, in gross tons:

Pig iron	729,072
Steel ingots	1,006,252
Rails	435,142
Shapes, bars, etc.	340,993
Total rolled steel	776,135

The blast furnaces are rated nominally at 150,000 tons annually, or 1,200,000 tons for the eight, and the finished rolled steel, when the works are running full, may be estimated at approximately the same total. Thus we see that for 1,200,000 tons of finished steel approximately half of it rails, there is involved an expenditure of $85,000,000, or $72 per ton of annual output, and this does not include coal or ore mines or transportation facilities other than docks and terminal railroad work. Of course, a portion of this may be written off, because town lots or buildings will be sold, or the buildings will furnish revenue, but as the total expenditures in the town, less credits for lands, lots and houses sold, have amounted only to $10,-509,325, the expenditures for the plant proper cannot be set at less than $75,000,000, which means $62.50 per ton of annual product.

This allotment per ton of output is very large compared with the standards of half a generation ago, when expenditures ran from $10 to $20 per ton, but it is small compared with the profits which ought to be realized, for 10 per cent to cover interest and depression would involve only $6.25 per ton. Depreciation in the steel industry is written chiefly by what occurs outside the plant, not by what occurs inside; in other words, by the progress of the industry. As the Gary plant is intended to be far ahead of anything yet attempted its depreciation may rightly be estimated as low for the next few years.

The Electrode Problem.

In any electrochemical process, be it electrolytic, electrothermic or a combination of the two, the cost of power is often a very large single item in the cost sheet. Among the other items, such as labor, repairs and renewals, interest and depreciation and general expenses, the second named includes a figure often large and usually uncertain, viz.: The cost of replacement of electrodes. The cost of power, on the other hand, is always large but rarely uncertain. Now in any new business undertaking uncertainty is usually the greatest deterrent. Indeed, the largest fortunes of this country have been gathered for the most part by men whose boldness is founded on the ability to see further and clearer through the haze than can the ordinary man. Darkness generates fear, but the light of day generates courage.

Accordingly, any light that can be shed on the commercial engineering of electrodes is of advantage to the wide and growing circle of metallurgists who are concerned with electrolytic and electric-furnace processes. The former are as a class older than the latter and hence have the advantage of the latter in the question of electrodes. For, in a properly developed electrolytic process, the cost of electrodes is not startling, varying, as it does, from 3 per cent to 10 per cent of the total cost. In the newer and wider field of the commercial electric furnace, especially where the electric furnace is operating on smelting processes or on refining, the cost of electrodes is sometimes as high as 25 per cent of the total cost of treatment of the successful process. And in the case of the unsuccessful process the cost of electrode renewals is so unexpectedly great as to cause often the abandonment of attempts that seemed at the first very hopeful.

Undoubtedly, great progress has been made in the past ten years in the manufacture of electrodes and also in the design of electrodes for their peculiar functions. We are confident that the next five years will witness even greater progress. The process of manufacturing electrodes is everywhere essentially the same. Briefly described, some form of carbonaceous material such as crushed "oil-coke" is mixed with tar and the mixture molded hot to the required form; the molded article

is then subjected to slowly increasing temperature until the tar is either volatilized or carbonized; thereby the solid particles of the original carbon are cemented together in a more or less compact mass; finally, the baked electrodes are annealed by slow cooling.

This process seems quite simple. In point of fact it is both simple and elementary, for a very satisfactory home-made electrode can be made for an intermittent type of electric furnace "in place," by tamping a hot mixture of tar, broken electrodes, and crushed coke in a form, "larding" it with a modern woman's hatpin, driving off the tar slowly with a wood fire and completing the cementing carbonization by auto-generated electric heat. But the process of making regular molded electrodes for a continuous electric furnace is not so simple as it looks at first glance.

In the first place, the chemical and physical properties of both the carbon and the binder are never uniform. Every chemist knows what a complex stuff tar is and also the varying idiosyncrasies of the carbon molecule. Next, to make a compact mass, the structure must have a certain density and at the same time a certain porosity. It seems like a paradox to combine these two diametrically opposed qualities in one article. But, nevertheless, it must be done. To insure firmness, the particles of carbon must be bonded well together, for otherwise the electrode obviously will be mechanically weak. If, on the other hand, the structure be very dense, the evolution of hydrocarbon gases in the baking will cause the development of many small places of intense local pressure with ensuing "checking" and resultant formation of planes of weakness in the finished article. In the third place, the baking must be done exceedingly slowly to reduce the internal pressure of hydrocarbon gases generated to such an extent that they can percolate through the electrode and get out without damaging the electrode. We see plainly that the whole operation is one that needs as much care and conscience as nursing a baby.

Now as the modern tendency is to build electric furnaces of great power requirements, the diameter of the electrodes asked for is, of course, greatly increased. It is apparent that with conditions such as they are the difficulties of manufacture are tremendously increased as the size of the electrode is increased. Carbons for arc lamps are not hard to make. In this case it is largely a question of cheapness gained by a large output. But to produce an electrode 24 in. in diameter and 120 in. in length is a triumph of mechanical and chemical engineering.

As is well known, we use in this country both graphitized and amorphous carbon electrodes. Each has its peculiar advantages and each has its peculiar disadvantages. Both are fairly resistant to the slightly oxidizing influences of the nearly neutral atmosphere of the average electric furnace. The graphitized article costs considerably more than the amorphous carbon electrode but it is a much better conductor of electricity. On the other hand, it is a better conductor of heat. The significance of these two facts has been discussed at such length in this journal a year ago in connection with the laws of electrode losses that there is no necessity to discuss this matter again at the present time. The graphitized electrode can be machined and so a composite electrode can be made, as is done at South Chicago and at Worcester. This is practically denied its rival. Both can be fashioned so that a new electrode can be "butt-connected" to the stub end of an old electrode and so the electrode is for all practical purposes fed, as needed, continuously into the furnace. The greatest point of superiority of the graphite electrode is usually unnoticed. This is its great power of resistance to sudden temperature changes. In the electric furnace industry, especially as developed in the United States, the workmen have never the skill in the art at first that is needed and developed later. The natural result is uneven working and its concomitant, bad temperature control. This affects the amorphous carbon electrode severely and the result is a high proportion of electrode scrap, even when the carbon electrodes have been made under good conditions.

It would appear that the process of baking the electrodes in electric furnaces of the Acheson type is inherently superior to the operation as conducted in the open-hearth furnace with its removable top and the covering of sand over the molded electrodes. The flow of heat from the innumerable points of local resistance is much more uniform in this style of electric furnace than in the gas-fired furnace, where the heat flows down through the sand covering to the entire mass of electrodes. As in a roasting furnace, the question of surface is of most importance. In the Acheson electric furnace the heat is generated in proximity to the place it is needed.

To cheapen the cost of production, it might be well to consider the manufacture of electrodes built up of standard elements of say 3 in. x 8 in. x 72 in. These elements could be produced far cheaper than the larger dimensioned electrodes. Practical experience seems to show that the built-up electrode fills the bill. The elements could be produced cheaply because the heat would only have to penetrate $1\frac{1}{2}$ in. and the hydrocarbons would have just this short distance to percolate outward.

It may also be well to consider a very slow and careful annealing when once the maximum temperature has been reached. A slow annealing greatly toughens the carbon and a slow adjustment of the internal strains makes for the desired quality of resistance to sudden temperature changes—a condition of the American climate that even affects the atmosphere of the American electric furnace.

Undoubtedly some of the large concerns using electrodes in quantity will in the future make their electrodes in their own plants. Ground "butts" and ground scrap electrodes are suitable ingredients of the mix and cheapen the cost of manufacture. A very profitable field of study is the application of the microscope to the microstructure of electrodes. The methods of attack in research which have developed the special sciences, known as metallography and petrography, could be well used to garner some solid scientific facts about electrode manufacture.

Indeed, the broad field of electric furnaces, their necessaries and accessories, such as voltage-regulators, pyrometers, refractories, and electrodes, is at the present outlook an ever-expanding one and in it progress is demanded. As the use of the electric furnace increases "the essential details" become better developed and easier of application. The smaller and apparently insignificant points of electrode manufacture which have been pointed out above, when incorporated in the "skill of the art," will render much easier the fruition of many electric-furnace processes.

The Death of Professor van't Hoff.

We regret to report the death of Professor J. H. van't Hoff on March 1, at Steglitz, near Berlin, Germany, at the age of 59 years. Professor van't Hoff was taken ill during the autumn of 1906 with pleurisy, which turned into tuberculosis, and he had not been well since. During the summer of 1907 he was critically ill for three months, but partially recovered, never, however, throwing off the insidious disease.

Jacobus Henricus van't Hoff was born in 1852 at Rotterdam, Holland, as the son of a physician, and was educated in the public school of that city. In 1869 he entered the Polytechnicum (Institute of Technology) at Delft and in 1871 the University of Leyden; subsequently he studied at the Universities of Bonn, under Kekule; of Paris, under Wurtz, and of Utrecht, where he received the degree of doctor of philosophy in 1874 and where he began teaching in 1876. He was called to Amsterdam in 1877, where he was soon made a professor. In 1894 he was called as professor of physical chemistry to the University of Berlin.

Professor van't Hoff's name will be connected forever with the history of modern physical chemistry, which owes to

J. H. van't Hoff

him directly some of the most fruitful and important broad generalizations and indirectly the impetus to an enormous amount of experimental work. "Wenn die Könige baun, haben die Kärrner zu thun."

In 1874, while still a student at Utrecht, he published his paper on the necessity of representing structural chemical formulas in a space of three dimensions, instead of a plane of two dimensions, and on the application of this new stereochemical method to the explanation of optical isomerism.

Van't Hoff's most important contributions to science, however, were made in two publications, issued in Amsterdam in 1884 and 1885 under the title "Etudes de Dynamique Chimique" and "Lois de l'Equilibre Chimique dens l'Etat Dilué, Gaseux ou Dissous." In these two papers those broad generalizations are contained which were so effective in determining the future course of the development of physical chemistry. First, van't Hoff's "principe de l'équilibre mobile" which replaced Berthelot's "principe du travail maximum." According to van't Hoff, when two chemical systems (represented by the two sides of a chemical equilibrium equation) are in equilibrium at a certain temperature, then a rise of temperature causes a shifting of the equilibrium toward that system (or toward that side of the equation of equilibrium) the formation of which is combined with absorption of heat.

Further, van't Hoff showed here how we have in the electrical energy of a galvanic cell a measure of the chemical affinity of the reactions taking place in the cell.

But perhaps most important of all was the generalization by which van't Hoff developed the parallelism between dilute solutions and gases. The laws for the osmotic pressure in dilute solutions and for the gas pressure in gases are identical. How the apparent discrepancies of this new rule from the facts in the case of electrolytes led directly to the electrolytic dissociation theory is too well known to be further recorded here.

Van't Hoff later took up the study of solid solutions, and the depth of his scientific imagination is indicated by his applications of physical chemistry to geology. In this connection his patient work on double salts concerning the Strassfurt salt beds must be mentioned, to which he devoted the last ten years of his life.

Program of New York Meeting of American Electrochemical Society.

The first convention of a national society to be held in the new Chemists' Building at 50-54 East 41st street, New York, is that of the American Electrochemical Society, the dates being April 6 to 8 (Thursday to Saturday).

There will be professional sessions for the reading and discussion of papers on the three mornings. All will be held in the Chemists' Club. The Friday and Saturday sessions will start at 9:30, the Thursday session at 10 o'clock, when the annual business meeting will be held. At a special evening session on Friday the retiring president, Professor W. H. Walker, will present his address.

For the afternoons the following **excursions** have been arranged: On *Thursday* afternoon the Laurel Hill works of the Nicholas Copper Company in Brooklyn will be visited, which is the largest copper refinery in the world.

On *Friday* afternoon the following optional visits have been arranged: (1) The new and splendidly equipped plant of the Hanson & Van Winkle Company in Newark, manufacturers of electroplating material and machinery, with a thoroughly modern demonstrating electroplating plant; or (2) electric furnace laboratory of Dr. F. J. Maywald and the photoengraving and electrotyping shops of the Moss Engraving Company in New York City; or (3) New York Electrical Testing Laboratories, the Chemical Laboratory of the College of New York and the Laboratories of Columbia University.

On *Saturday* afternoon an excursion will be made to the Perth Amboy plant of the American Smelting & Refining Company. It comprises ore smelters, lead refining plant, electrolytic copper refining, electrolytic silver refining and the bessemerizing of leady copper matter in basic-lined converters. This immense plant refines, per month, 7,500 tons of copper, 8,000 tons of lead, 3,000,000 ounces of silver and 20,000 ounces of gold. In doing this it smelts 15,000 tons of ore and bessemerizes 1500 tons of leady copper matter. Attention is particularly directed to the basic-lined converters, the latest improvements in the metallurgy of copper.

Social Functions.—On Thursday evening a subscription dinner will be held at the Chemists' Club. On the evening of Saturday, April 8, the New York section of the American Electrochemical Society tenders an invitation smoker to the visiting members and guests of the society and to the Chemists' Club.

The program of **papers** is as follows:

Thursday morning after the annual business session, which begins at 10 o'clock.

Report of the Committee on Standard Tests for Dry Cells: C. F. Burgess.

The Testing of Dry Cells: W. B. Pretz.

Electrically Fused Alumina as a Refractory: L. E. Saunders.

A New Electric Resistance Furnace: F. A. J. Fitzgerald.

A New Laboratory Electric Furnace: M. M. Kohn.

An Electric Furnace for Heating Bars and Billets: Thaddeus F. Baily.

The Johnson Electric Zinc Furnace: J. W. Richards.

The Condensation of Zinc from Electric Furnaces: F. T. Snyder.

Reliability of Electric Furnaces for Commercial Work: F. T. Snyder.

Friday morning, 9:30.

Electric Cyanamide Process for Gold Ores: J. F. Clancy.

The Electrolytic System of Amalgamating Gold Ores: E. E. Carey.

The Electrolytic Corrosion of Electroplated Objects: W. S. Landis.

Electrolytic Refining as a Step in the Production of Steel: C. F. Burgess.

Some Problems of the Electroplater: G. B. Hogaboom.

The Haas-Oettel Electrolytic Cell: E. E. Niswonger.

Electrical Heating for Preventing Superheating of Liquids: J. Howard Mathews.

A Mercurous Perchlorate Coulometer—Preliminary Experiments: F. C. Mathers.

Some Observations on the Laboratory Production of Aluminum: H. K. Richardson.

Exhibition of the Schoenherr Arc for Fixatives of Atmospheric Nitrogen: J. W. Turrentine.

Electric Discharges in Gases: L. A. Parsons.

The Mechanism of Electrolytic Transfer: J. W. Richards.

Polarization in Its Relation to the Decomposition Pressure of Electrolytes: O. P. Watts.

Friday evening, 8:15. Joint meeting with the New York section of the American Chemical Society.

Presidential Address: Dr. W. H. Walker.

Lecture by Dr. Harrison E. Patten on "The Relation of Surface Tension and Electrochemical Action."

Saturday morning, 9:30.

Electric Furnaces for the Manufacture of Steel: James Lyman.

Some Experiences with the Electric Furnace at South Chicago: C. G. Osborne.

Electric Steel Processes as Competitors of the Bessemer and Open Hearth: A. E. Greene.

Design of a Fifty-Ton Induction Electric Steel Furnace: A. Hiorth.

A New Type of Electric Furnace: Carl Hering.

Electric Furnace Treatment of Nickel Ore: W. L. Morrison.

An Electrolytic Furnace Method for Producing the Rare Metals: J. W. Beckman.

The Advantages of Keokuk, Iowa, for Electrochemical Industries: F. P. H. Knight.

The Advantages of Maine for Electrochemical Industries: C. Vey Holman.

The Western Metallurgical Field.

Magnetic Roasting.

The treatment of those Western ores which contain a mixture of iron and zinc sulphides, pyrite and blende is in a large measure dependent on magnetic roasting and separation. The magnetic roast is a delicate operation and the devices used for producing it are not always sufficiently under the control of the operator to turn out a uniform product. Overroasting produces oxide of iron, which frequently is seen in roasted ore as a reddish substance, and which reduces the efficiency of the subsequent magnetic separation.

The magnetic roast usually is produced in furnaces not unlike those used for desulphurizing roasting. They have certain inherent drawbacks which, in a measure, make them unfit, or at least not the best, for magnetic work. As a rule the ore is exposed to heat for too long a time, and all of the particles are not evenly exposed, so that a variable product results. By rabbling a deep bed of fine ore on a hearth one cannot be certain that all particles receive the same degree of heat for the same time, although the purpose of the rabbling is to accomplish this result as well as to advance the ore through the furnace.

A new idea in magnetic roasting has been applied by Mr. A. R. Wilfley, known for his invention of the concentrating table of that name. Mr. Wilfley has tried to evolve a furnace that would give to all ore particles as nearly the same treatment as it is possible to do in a commercial roasting furnace. The furnace consists of a circular, rotating roasting hearth, with an auxiliary fire box, feeding device and means for removing the ore from the hearth when roasted. By an adaptation of the roller feed, such as is used on some magnetic and electrostatic separators, the ore is fed onto the hearth in a very shallow bed, approximately one grain deep. The hearth rotates in the opposite direction to the path of the hot-furnace gases, so that the ore gradually advances through an atmosphere of increasing temperature until it is finally removed from the hearth after one revolution. The points of feed and removal of the ore are in close proximity between the inlet and outlet of the furnace gases. The device for removing the ore from the hearth is a specially constructed suction nozzle, which is connected with a suitable receptacle.

A number of advantages will be apparent in this construction. There will be little tendency for the ore particles to become agglomerated; one particle will have the same treatment as another; the rate of speed of the hearth can be regulated to give exactly the right time of exposure according to the temperature and the roast is immediately arrested when the ore is cooled in the suction nozzle. Naturally the time of exposure of the ore to heat is very short, one to three minutes sufficing to produce the same result that is accomplished in an ordinary roaster in the same number of hours. The capacity of an experimental machine has shown that 7.5 sq. ft. of hearth area per minute will give a magnetic roast to one ton of ore in 24 hours.

Legislation.

This is the biennial period when Western Legislatures consider, among other things, ways and means to control the metallurgical and mining industries in the interest of the producer of ore, as well as methods for obtaining more State revenue from both industries. Two Colorado bills show the trend of legislation this year. Their subject matter is not exactly new and it is doubtful if either of them will pass, but they are interesting as reflecting the attitude of legislators.

The Joyce bill for regulating metallurgical plants seeks to prevent the imposition of unjust or unreasonable rates on ore treatment, the giving or receiving of rebates, or any other form of discrimination, and empowers the State commissioner of mines to enforce the provisions of the bill. Some years ago when the smelting of ores was the foremost metallurgical industry in Colorado there was considerable complaint against the smelter monopoly on account of treatment rates. It was alleged that large shippers were favored at the expense of the small, and that no uniform tariff existed for all shippers of the same kind of ore. The difficulty then, as now, was to make workable provisions for enforcing regulation of the industry.

The Joyce bill seeks to empower the State commissioner of mines to enforce the provisions of the bill, but such a thing would be almost impossible, even if conditions urgently demanded rate regulation. Any corporation strong enough to control the metallurgical situation would, under our present system of politics, first see that an acceptable commissioner of mines was appointed, after which the provisions of the law would be of little effect.

The McPolin bill for the regulation of the practice of assaying, and requiring the registration and examination of all assayers in the State, embodies another idea that frequently has been put forward. It undoubtedly springs from the abuses that have been perpetrated in the name of assaying by men who have taken advantage of a respectable calling to engage in criminal practices. Every rich mining camp in the West has had to fight the "high graders" who run alleged assay offices and buy small lots of stolen high-grade ore. In the absence of adequate means of coping with them the leading companies frequently have taken matters in their own hands

and have forcibly stopped the practice of the high-graders.

The proposed bill for the licensing of assayers is apparently another step in the elimination of the high grader as well as the incompetent workman. As with most bills of good intent the carrying out of its provisions might prove difficult. The greatest care would have to be exercised in the selection of the proposed board of examiners, for they have the power to accept or reject applicants, to supervise their work in practice and revoke licenses in case of unprofessional conduct or incompetency.

The bill would have several beneficial effects if passed and properly enforced. The public would be protected from unscrupulous assayers who sometimes falsify reports for financial considerations. Legitimate assayers would be accepted by the public on the face of their standing with the board of examiners.

No hardship would thereby be worked, and as all assayers in metal mining districts are engaged in the same line of work there would not be the objection to licensing them which is quoted against the licensing of civil engineers, for example, in which profession all members are not engaged in the same class of work and ought not to be required to show proficiency in all branches of the profession.

Utah.

A sequel to the smoke suits brought by the farmers of the Salt Lake Valley against the local smelters several years ago is the recent decision of the Bingham Mines Company, owner of the old Bingham Consolidated Smelter, to raze that plant and dispose of the equipment. This smelter was put in operation in 1901 and operated successfully until the close of 1907, when it was closed by order of the court on account of the damages caused by its fumes to surrounding agricultural land. The plant was well equipped, having five blast furnaces, one reverberatory, four McDougall roasters and the complementary converting department. When the plant was closed there were plans on foot to enlarge and improve it, but these were abandoned and the closing of the plant followed.

A recent transaction of importance was the leasing of the Ontario property at Park City, Utah, to Salt Lake men. For two years past Mr. Henry M. Crowther has represented a company which has been experimenting on the old stope fillings of the Ontario, ascertaining their value and amenability to modern methods of metallurgy. Originally the Ontario produced very rich ore which was treated by the Russell process. The average grade was over $100 per ton, and the low-grade ore was used as filling.

It is said that there are about 1,000,000 tons of this material, and it is the intention of the leasing company to remove and treat it.

The experimental work has shown that the methods of fine grinding, agitating in cyanide solution, filter pressing and precipitating by zinc dust developed in recent years will permit an extraction of over 95 per cent of the gold and about 80 per cent of the silver. With such an installation in a remodeled mill it is expected that 300 tons of ore will be treated daily. The improvements will cost in the neighborhood of $200,000.

The New Copper Mills.

The first unit of the large Ray Consolidated mill in Arizona has been put in operation and from this time on the company will be classed among the producers. The Miami also is expected to be in operation by the time this report reaches our readers.

The Chino mill in New Mexico is not expected to be in operation until July, but when it commences it will have 30 years' ore supply at the present rated capacity of the mill. The latest reports from Chino state that 45,000,000 tons of copper ore have been developed, and that 70 per cent of this will be mined by steam shovel.

The Non-Ferrous Metal Market.

The general improvement in the spelter market and the decline in prices for spot tin have been the principal features of the metal market since our last report. In copper and lead the volume of business is fair, but only for immediate needs of manufacturers.

Copper.—The March market has been without special feature, both domestic and foreign demands being light. It is generally understood that the largest transactions were at concessions in price, as the sellers seemed eager to get business. Lake copper is quoted at 12⅜ to 12⅝ cents and electrolytic at 12.15 to 12.20.

Lead.—No improvement has been noted in this market, despite the expectation that the usual demand would occur with the coming of spring. Considerable Missouri lead has been sold and the St. Louis market has dropped to 4.22½ to 4.25 cents. The New York market quotes 4.37½ to 4.40 cents.

Spelter.—Improvement in the galvanizing trade has stimulated the spelter market somewhat, with the result that prices are a little higher than last month. St. Louis spelter is quoted at 5.45 to 5.50 and the New York market at 5.60 to 5.65 cents.

Tin.—The quotations on this metal have been erratic during March. In the beginning of the month the metal was expected to show advances owing to the operations of the syndicate which was supposed to have taken advantage of the weakness developed in February. Foreign markets showed a steady decline, however, and the domestic corner was broken. Future tin has held its own and spot has suffered the decline. March tin was quoted at about 40⅝ cents.

The Iron and Steel Market.

March showed a definite decline in the rate of buying of finished steel products, which had increased so rapidly late in January and early in February. The decrease is not traceable altogether to a decrease in general business activity, although it does appear that general business is hardly as active as it was early in the year. Nor is it traceable to the famous rate decisions of the Interstate Commerce Commission, made Feb. 22. It appears rather that during December and the fore part of January a considerable tonnage of requirements backed up, partly because buyers at that time were fearful of a decline in the market, and partly because they wished to avoid incurring obligations or increasing stocks until after the inventory date. The release of this business, at a time when requirements were increasing, effected a rapid increase in the rate of booking orders. To use figures for conciseness rather than precise accuracy, bookings of orders for finished steel products averaged 35 to 40 per cent of capacity in December and the early part of January, 75 to 85 per cent 'ate in January and in February and 55 to 65 per cent during March.

The iron and steel trade regarded rather seriously the claims made by the railroads during the pendency of the rate cases before the Interstate Commerce Commission that an adverse decision would greatly curtail their buying power, and was disappointed at the decisions rendered. However, no direct results have been traced. No orders for railroad material have been canceled, or enquiries withdrawn, while along certain lines there seems to have been a slight increase in the volume of railroad buying. In the last analysis, there is good reason to expect the throttling of the rate advancing tendency to prove favorable to the iron industry. The railroads had reached a point where large extensions were very improbable. Their existing equipment seems to be fairly adequate to the conduct of the business offered, and large consumption of iron and steel for extensions to facilities was not to be expected. On the other hand, the railroads have reached a point where they are wearing out material very rapidly, their ton-mileage of freight having doubled every 10 or 12 years. The replacement of worn-

out material, whether in brake shoes, entire cars, or rails, does not involve fresh borrowing of capital, being an ordinary item of expense, and whatever tends to increase the volume of traffic, as the curbing of the rate advancing tendency does, makes for more wearing out of material and more demand along the only line in which any large demand was to have been expected.

While bookings in the finished steel trade decreased somewhat in March, production increased. It required time for the mills to limber up and the heavy bookings in February resulted in heavy operations in March. The mills ran at about 50 per cent of capacity in December and January, about 60 per cent in February and about 75 per cent in March. It is evident that they will not be able to maintain the present pace of production unless there is an increase in buying. This is to be expected as spring weather comes.

There is no disposition to buy ahead, and current orders are for current requirements. By far the bulk of the bookings in March were in the form of specifications against old contracts, there being relatively little strictly new buying.

Prices of finished steel products are being held by the mills all along the line, there being apparently a firm conviction that at least as large a tonnage of business will result from present prices as would be brought out by lower prices, and there is evidently also a firm conviction that any departures from existing prices by individual producers would quickly inaugurate a general reduction, in which the original cutters would suffer as much as their neighbors.

Effective at the opening of business Monday, March 6, wire products were advanced $1 per ton, this following an advance of a dollar a ton made effective Jan. 23. The mills are adhering strictly to the advanced prices, but the same cannot be said of jobbers, who are cutting the market more or less generally by a dollar a ton. They did a little cutting following the first advance, and the practice is now more general. The trade custom is to book jobbers with contracts prior to an advance, these contracts being good for specifications during the ensuing 60 days. After the first advance jobbers specified liberally on their old contracts, but retailers and large consumers did not take hold in like manner, with the result that jobbers were left with large stocks, and at the moment they are buying rather sparingly.

On March 10 the United States Steel Corporation reported its unfilled orders at the close of business Feb. 28 at 3,-400,543 tons, representing a gain of 289,624 tons during February, against a gain of 436,162 tons in January, and a continued loss during 1910 aggregating 3,252,274 tons for the year.

Pig Iron.

The total turnover in pig iron in March was perhaps a trifle larger than in February, that month having shown a good gain over December or January. There was a barely perceptible tendency toward higher prices in March. At Buffalo and Cleveland the asking prices of furnaces were advanced about 25 cents, but only after considerable sales had been made at the low point. In eastern Pennsylvania a sharp rise occurred in basic iron, from $14.50 to $15.25, delivered Philadelphia. In the South the $11, Birmingham, basis was simply maintained, with $11.25 to $11.50 demanded for deliveries after July 1. In the valley market nothing of interest occurred except the development of a price on foundry iron for delivery over the second half, at 25 cents advance over the prompt and second quarter market. Basic iron was practically dormant, the sales noted in last report seeming to have filled consumers' requirements. Bessemer moved in small lots at the regular price. We quote at valley furnaces, 90 cents higher delivered Pittsburgh: Bessemer, $15; basic, $13.75 to $14; No. 2 foundry, $14 to $14.25; malleable, $13.75.

Steel.

Shipments of semi-finished steel in March showed a large increase over February, but almost entirely by reason of heavier specifications on existing contracts, there being very little fresh

buying. Bessemer and open-hearth billets remain quotable at $23, Pittsburgh or Youngstown, and sheet bars at $24. Several of the wire mills advanced their price on rods from $29 to $30 at the time of the advance in wire products, but it seems probable that material can be picked up at the old figure.

Finished Steel.

Finished steel prices are held firmly all along the line, with the exception of shading on wire products by some jobbers, as already noted. Prices f. o. b. Pittsburgh, except where otherwise noted, are as follows:

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f. o. b. mill except Colorado.

Plates, 1.40 cents for tank quality.

Shapes, 1.40 cents for beams and channels, 3 in. to 15 in. inclusive, zees and angles, 2 x 3 and larger.

Steel bars, 1.40 cents, base; iron bars, 1.35 cents, Pittsburgh; 1.25 cents, Chicago.

Wire nails, $1.80, base, per keg; plain wire, 1.60 cents, base; galvanized barb wire, 2.10 cents; painted barb wire, 1.80 cents.

Black sheets, 28 gage, 2.20 cents; galvanized, 3.20 cents; blue annealed, 10 gage, 1.65 cents; painted corrugated roofing, $1.55 per square; galvanized, $2.75.

International Congress of Applied Chemistry, 1912

A preliminary announcement has just been issued giving the present status of the organization of the congress to be held in this country from Sept. 4 to 13, 1912.

This same announcement contains tentative rules on the publication of papers and on sectional procedure and the suggestion of a special interests' registration bureau. As these are matters of greatest immediate importance, they are given here slightly abbreviated. We will be glad to place our correspondence columns at the disposal of our readers for discussion and criticism. These tentative rules should be made final as soon as possible, but before this is done they should be clearly understood and discussed.

Tentative Rules Governing the Receipt of Papers for Presentation or Publication.

All papers should be in the hands of the American committee on or before July 1, 1912. All such papers should be presented in *duplicate,* legibly written, but preferably typewritten. *Each paper must be accompanied by an abstract* thereof also in duplicate, legibly written, but preferably typewritten.

All papers received prior to July 1, 1912, and accepted for publication will be printed prior to the meeting of the congress and grouped according to the sections to which they are assigned; papers received after July 1, 1912, and accepted for publication will be printed prior to the meeting of the congress if practicable, but it cannot be guaranteed that they will be placed in the section to which they belong, but they may appear in an appendix.

The American committee will neither revise nor edit any papers or abstracts; papers received for publication will be printed *in extenso* as offered, or only the abstract accompanying the full paper will be printed, or the paper will be printed by title only, together with the name and post-office address of its author, or the paper will not be printed at all, as may be decided in each case by the committee on papers and publications.

Authors will not receive printer's proofs of papers or abstracts; authors must do their proofreading on the manuscript; whatever is printed by the American committee will be printed in exact accordance with whichever of the authors' manuscripts is selected for publication.

Discussions will be recorded in the official language in which they are uttered, and participants in the discussions will have an opportunity of editing the manuscript report of such discussion; the American committees will print from such edited

manuscript report of the discussion, and printer's proofs will not be sent to participants.

No paper which has previously been published shall be read at the eighth congress nor printed in its final report without the consent of the sectional executive committee, the committee on papers and publications and the executive committees of the eighth congress having first been obtained.

The American committee will proceed to print the papers during the first half of July, 1912. The size of the edition printed will be determined by the number of membership fees received on or before July 1, 1912.

Persons contemplating membership in the congress should have their membership completed prior to July 1, 1912, in order that they may be sure of receiving a copy of the report of the congress. Membership fees can be received after July 1, 1912, only as subject to the condition that copies of the report of the congress cannot be guaranteed and will be supplied only until the number of extra copies printed is exhausted.

Tentative Rules on Sectional Procedure.

The presentation of the subject matter of any paper before any section or subsection shall not exceed ten minutes; if the original paper requires more than ten minutes for reading, it must be suitably condensed.

All participants in discussions must speak from the rostrum and not from the floor of the house; where practicable, discussions should be handed in to the sectional secretary in writing and in advance.

Discussion is limited to five minutes for each participant unless consent of those in attendance be obtained for an extension of that time.

According to the proposed order of business, the reading of minutes of the preceeding meeting is to be omitted except in so far as they may contain resolutions or motions calling for action by the section or subsection at that meeting.

After the reading of the minutes, if any be read, the order of the day shall be taken up.

The sessions of sections and subsections will begin at 10 in the forenoon and last until 12 noon; the afternooon sessions will begin at 2 and close at 4 o'clock, except on those afternoons on which there shall be public or general lectures, when the afternoon sessions will begin at 1 o'clock and end at 3 Any papers on the order of the day not reached during the session to which they are allotted will be taken up at the meeting next succeeding in which the order of the day is completed prior to the hour of adjournment, and not otherwise. No paper is to be taken up for presentation within 15 minutes of the adjournment hour, except by unanimous vote of all members present.

Special Interests Registration Bureau.

It is proposed to establish at the eighth congress a *Special Interests Registration Bureau.* This will be distinct from the Central Registration Bureau. Members concerned with any one of the very special phases of chemical industry, and prepared to exchange information with their professional brethren, may register under such specialties. The list of registrants in each specialty will be made accessible to all, either in a pamphlet printed and distributed daily or by exhibiting copies of the typewritten list on bulletin boards. Is such a Special Interests Registration Bureau desirable? If such a special registration is established, what are the titles of the different special phases which should appear at the head of such registration lists in order to be sure of meeting reasonable demands for a minutely specialized classification of chemical interests?

These two questions should be discussed and answered by chemical and allied societies as well as by individual chemists in order to enable the American committee to decide the advisability of such a bureau.

The opening meeting of the congress will be held at Washington, D. C., on September 4, 1912. The other meetings, business and scientific, will all be held in New York. This will begin on Friday, September 6, 1912, and will end on Friday, September 13, 1912. The president of the United States is the patron of the congress, Dr. E. W. Morley the honorary president, Dr. W. H. Nichols the president.

Dr. B. C. Hesse, 25 Broad Street, New York City, is the secretary of the congress.

CORRESPONDENCE

Separation of Oxygen by Cold.

To the Editor of Metallurgical and Chemical Engineering:

Sir:—In the January issue of your journal there is an article with the above title which constituted the address of Mr. James Swinburne before the Faraday Society in London.

We are accustomed to receive as gospel in the scientific world anything which bears the hall mark of the Faraday Society, but some of the statements in that paper are so at variance with other statements made before equally august bodies of scientists that it seems worth while to call attention to the discrepancies to the end that the truth may be brought out more clearly and definitely.

One of the statements which constitutes a discrepancy from the accepted facts involves a purely theoretical consideration—the other a purely practical one. The former is contained in the sentence:

"The mixture of two mutually inert gases thus involves increase of entropy. . . . As this depends solely on the logarithms of the free paths it depends in the case of two gases at the same temperature and pressure only on the relative volumes of the gases before they are mixed."

The immortal Clausius invented entropy in the broadest sense—that is, he discovered the function and took the name from the Greek. His definition was, roughly, that the change in entropy of a given body between two temperatures was the integral of the infinitesimal quantities of heat passing at each temperature divided by that temperature. The whole of thermo-dynamics is founded on this definition. There may be mathematical laws which give a relation between the entropy of a gas and the length of the free path of its molecules, but it is not evident to this deponent how there can be any increase in entropy by mixing volumes of different gases at the same temperature and pressure. It would seem, in fact, that it were demonstrable that this were a mathematical impossibility.

If your journal is to give the weight of its countenance to articles containing statements so at variance with commonly accepted physical definitions it owes to its readers some explanation of the differences, or a disclaimer of responsibility for the ideas set forth.

The other discrepancy involves a difference in absolute facts between the statements of Mr. Swinburne and those made by M. L. Marchis before the International Congress of Refrigerative Industries, held, I think, in Paris in 1909. The title of M. Marchis' paper is "The Production of Low Temperature and Refrigeration." It is republished in the report of the Smithsonian Institution for 1910, recently issued. All the articles republished in this report are taken from the very highest authorities and publication therein implies the approval of one of the leading scientific bodies of America.

On the subject of separating oxygen from nitrogen Mr. Swinburne declares that to produce a ton (of oxygen) would need 120,000 kw-hours. This result he reaches by a theoretical reasoning which the present writer is unfortunately incapable of understanding, but the statement is clear and distinct.

On the other hand, M. Marchis states that the Société L'Air Liquide has built apparatus which actually do deliver 100 cu. m of pure oxygen per hour, and that these apparatus yield 1.19 cu. m of pure oxygen per hp-hour, or 3.67 lb. If Mr. Swinburne were using the English ton of 2240 lb., 3.67 lb. would go into this 610 times, and, therefore, to produce one ton of oxygen would require 610 hp-hours, or 455 kw-hours.

This is about 1/300 part of the power declared by Mr. Swinburne to be necessary for this operation.

The writer personally has a letter from the Sociétié L'Air Liquide in which they offer to furnish an apparatus which will deliver 500 cu. m of pure oxygen per hour, of 1545 lb., with only the power required to compress 2500 cu. m of air per hour to a pressure of 10 atmospheres. The power required for this operation in a good compressor would not exceed 300 hp, so that that for a ton would not exceed 435 hp, probably not over 400 hp. This is just 1/400 part of the power claimed to be required by Mr. Swinburne.

The discrepancy between the power required for the apparatus of 500 cu. m and that of 100 cu. m capacity is easily accounted for by the greater efficiency to be expected from the larger apparatus.

It is well to remember that the first steam-propelled vessel which came from England to the shores of the United States carried copies of a pamphlet which proved mathematically the impossibility of a steamship ever crossing the Atlantic. Even in science the prediction of the impossible is dangerous.

Think what a fool anyone would have been thought 15 years ago who declared that a substance would eventually be found which gave out heat in large quantities without combustion and kept it up for an almost infinite time! Yet this impossibility of that recent date is now serving as the key to unlock many of Nature's doors hitherto sealed to us.

This letter is written in the hope that someone capable of doing so will explain these frightful instances of the "doctors disagreeing" for the benefit of an unfortunate engineer, himself unable to read the riddle.

JOHN J. SMITH.

[We trust that our correspondent's interesting letter will bring forward an instructive discussion and the desired information.

With respect to the theoretical point raised by him in the first place, we are unable to see how any discrepancy can be claimed between the classical theory of thermodynamics and Mr. Swinburne's statement that when two mutually inert gases mix (so that the mixture occupies a volume equal to the sum of the volumes of the two gases before the mixture) the entropy is increased. According to Clausius' principle that for any irreversible process in nature the entropy increases, Mr. Swinburne's statement means simply that the mixture of two gases in the way described is irreversible, i.e., that it is an impossibility to separate the two gases from the mixture again so as to bring them back into their original separate condition, without causing some other change as a matter of compensation. Mr. Swinburne's statement means that a separation of the gases, as just sketched, is impossible whatever kind of cyclically operating machine one may try for the purpose, the only condition being that when the gases are separated, everything else, including the condition of the cyclic machines, should be exactly in the same condition as at the beginning of the process. On closer analysis the impossibility of the imagined process will be found to lie in the fulfilment of the last-named condition.

To calculate numerically the increase of entropy involved in the mixture of the two gases we must devise an imaginary process by which (for instance, with the aid of imaginary semipermeable diaphragms) the mixture of gases is separated into its constituents, every infinitesimal step of this process being a reversible equilibrium step (f.i., if heat is given off to or absorbed from an outside heat reservoir there must be temperature equilibrium between our system of gases and the heat reservoir). The Clausius integral referred to by our correspondent, of the ratio of the infinitely small heat quantity to the absolute temperature, extended over our whole imaginary process, must then be calculated. In this way, which cannot now be sketched in greater detail, the numerical value of the increase of entropy due to the mixture of the two gases is found. The entropy increase, derived in a slightly different way, may be found, for instance, in Planck's Vorlesungen über

Thermodynamik, §238, where it is shown to have an essentially positive value.

We may call attention here to an excellent and highly instructive little book by Mr. James Swinburne on "Entropy or Thermodynamics from an Engineer's Standpoint" (London, 1904). In this book some of the fundamental questions about entropy are clearly explained in accordance with classical thermodynamics; that is, in contradistinction to the vague statements often found in engineering textbooks—which would seem to be at the bottom of the theoretical scruples of our correspondent. As to the discrepancy between Mr. Swinburne's theoretical results and the practical results to which our correspondent refers, we trust an explanation will be forthcoming. —EDITOR.]

Heat Losses Through Furnace Walls.

To the Editor of Metallurgical and Chemical Engineering:

SIR:—Mr. Carl Hering, in your March number, page 125, makes some criticisms of remarks which I made in Chicago before the American Electrochemical Society in discussing Mr. Snyder's paper on the "Heat Losses Through Furnace Walls." My remarks are in Volume XVIII of the *Transactions* of this society, on pages 245 and 247. After carefully rereading them and considering Mr. Hering's criticisms I feel convinced that the best answer to the latter is simply to repeat the former. My words were as follows:

"I think it is extremely important for electric furnace manufacturers, particularly, to study the question of the amount of heat transferred through the furnace walls. If they are experimenting with a given thickness of wall with a given furnace, there is one particular which it is important to bear in mind. Given an electric furnace with a wall of a given thickness, and experimenting with different materials in the walls to find the one which conducts the least heat from the furnace, you have a very good way of comparing the different materials by measuring the temperature of the outside of the furnace shell. The total heat loss from the furnace will vary with the temperature of its outside. I found a very convenient means of doing this by taking an iron-nickel thermo-couple and holding the junction against the furnace wall. In that way you can measure temperatures up to 500° C. With a given external surface the higher the temperature outside, the more heat you are losing; and the more efficient the heat insulation the lower the outside wall temperature will be." * * *

"I meant to say that for a given thickness of furnace wall, comparing different materials in that same thickness of furnace wall, you can measure the temperature of the outside and thus get a comparison of different materials composing a wall of given thickness."

And now, Mr. Editor, allow me to admit that I have repeated these words not for the pleasure there might be in refuting Mr. Hering's criticisms, but because of their real importance to all electric furnace constructors. If so keen a scientist as Mr. Hering is so slow in seeing their truth, and even rushes into print to confute them, it is surely worth while repeating them and commending them again to the serious attention of all interested, with the emphatic assurance that, as will be evident on proper reflection, they are important and true.

Lehigh University, March 12.   JOS. W. RICHARDS.

* * *

To the Editor of Metallurgical and Chemical Engineering:

SIR:—In the above letter of Professor Richards I notice that he does not quote all that he said in that original discussion, but that he has now omitted some of the very parts which gave rise to the present discussion; the portions now quoted in his letter, when read by themselves, would have called for a different comment than the one I made in my previous letter. I think that almost anyone reading all that he originally said, especially on page 246 of the *Transactions* (which page I notice he omits referring to in his letter), and realizing that the last paragraph quoted above beginning with

"I *meant* to say" certainly seems to signify that he did not mean what he had said before and was given as a *correction* of his former statements, will agree with me that, taken as a whole, it was quite confusing and that it was difficult to find out what he really did mean to say.

One of the confusing statements omitted from his present quotation is: "The higher the external temperature the less the heat gradient from the inside to the outside and, tnerefore, the less heat is being taken out of the furnace." But in the part quoted above he says that a higher outside temperature (hence a *less heat gradient*) means a *greater* loss, hence just the contrary; why should a less heat gradient sometimes mean a less loss and at other times a greater loss; he neither then nor now offers an explanation of this discrepancy or apparent contradiction. And in his apparent correction of this confusion (on page 247, namely, the last paragraph quoted by him above) he omits entirely to say whether he then meant that it is a higher or a lower outside temperature that indicates the greater loss. This certainly seems to indicate that he was not then sure which it was, and did not wish to commit himself.

It was because I thought others, like myself, might be confused by this apparent contradiction that I endeavored to show in the March issue that in the general case, barring the minor influences, the drop of temperature by itself, or the' heat gradient, is not necessarily a measure of the relative losses, although it is in some specific cases.

Whatever Professor Richards meant to say, the main feature of his remarks certainly was that the temperature of the outside of the wall, and therefore the heat gradient when the thickness is the same, was a true measure of the loss, and was even "a *very good* way of comparing the different materials" in the walls. It is also a fact that in his final corrected statement he refrains from saying whether a greater heat gradient means a greater or a less loss.

I have endeavored to explain the true facts in the case in an article published elsewhere in this issue, the general conclusions in which are that the drop of temperature in the walls, as a general rule, is by no means a criterion of the loss, but that it is so in stated specific cases; that under certain specified conditions the higher the outside voltage (that is, the less the heat gradient) the less the loss, and under others, the greater the loss; but that in the latter case (which appears to be the one he now wants it understood that he meant) the outside temperature would be a very poor and in fact dangerously bad method of measuring the goodness of the material of the walls, and would therefore surely not be "a very good way of comparing different materials" and should be condemned rather than encouraged. It was therefore to his credit that in my first reply I did not assume that he wanted to be understood that he was referring to this particular case.

If, for instance, he were to measure the same furnace in summer and again in winter without knowing it was the same one he would have to erroneously conclude that the one measured in winter had the better wall material. Or if the supposedly constant inside temperatures in two different tests of two comparative furnaces happened to differ somewhat in the two cases, which is very likely to be the case, the relative positions of the two wall materials as to their insulating power might actually be reversed! I have shown by actual examples in that article that the outside temperatures, even under the conditions most favorable to Professor Richards' present apparent argument, which conditions it would be practically impossible to realize in practice, would vary so little with very widely differing materials that it would be very inadvisable to attempt to draw such conclusions from them as he recommends, or to place the reliance that he does on the results.

If Professor Richards now means what I understood the latter part of his original discussion to infer that he did not mean to say, namely, that the greater the heat gradient the

less the loss, I can hardly assume all the blame for having at first misunderstood what he meant by the words he then used, and for being "so slow in seeing their truth" (sic), and I would respectfully suggest that he might have explained himself more clearly if he understood it clearly at that time.

My reply to his letter, therefore, is, that I regret that I cannot attach the same "real importance" which he does to either the "words" he used or to his method, and that I cannot endorse his "commending them (both) again to the serious attention of all interested, with the repeated assurance that, as will be evident on proper reflection, they are important." Whether my "reflections" on this subject are "proper" or improper must be judged from my views as expressed in the article on another page of this issue. If the statements in that article are true and correct, as I believe they are, and if they have assisted somewhat in clarifying the subject, I have no regret that I "even rushed into print," which under such circumstances I consider a professional duty to do.

Philadelphia, Pa., March 15.   Carl Hering.

* * *

To the Editor of Metallurgical and Chemical Engineering:

Sir:—Referring to above communication from Mr. Hering I am sorry that he is apparently so slow in appreciating the correctness of my original remarks which he criticises.

My remarks were directed to bringing out two principles:

(1) If you keep all other conditions the same, and substitute one lining material for another in a furnace, then the better heat insulator said lining is the lower will be the temperature of the outside surface of the furnace and vice versa. Therefore, when experimenting with linings and substituting one material for another in the wall, the measurement of the outside surface temperature is a reliable index of the heat insulating quality of the wall material, the lower outside surface temperature indicating a better heat insulator and vice versa

(2) If you keep all other conditions the same, and substitute one kind of outside surface for another on a furnace, then the less heat radiating and conducting power said surface has the less heat will be lost from the furnace, although the outside surface temperature will be *higher* than it was before, and *per contra* the greater the heat radiating and conducting power said surface has the more heat will be lost from the furnace, although the outside surface temperature will be *lower* than it was before.

Fearing that the latter generalization was too difficult to be seen at once I expatiated upon it, explaining that the paradoxical statement would be better understood if it was realized that, in case (2), when varying the outside surface only, the higher the external surface temperature the less the heat gradient through the furnace wall, and therefore the less heat could pass from the furnace.

Mr. Hering has apparently not been able to see through these generalizations. He applies what I said about the heat gradient in the walls when varying the outside surface (case 2) to the conditions when varying the material in the walls and keeping the outside surface the same (case 1)—to which, of course, they do not apply.

In closing, I would say that I consider my original remarks, criticised by Mr. Hering, as clear and correct. They are not easy to understand, it is true, and if they had been merely self-evident platitudes there would have been no justification for my saying them. Mr. Hering has apparently, in good faith, been unable to understand them. If any reader of this journal is inclined to think the criticisms made upon them correct I would ask only one favor of him, viz., that he *study* carefully my original remarks, in Vol. XVIII of the *Transactions* of the American Electrochemical Society, pages 245, 246 and 247, and in doing so avoid the mistake which Mr. Hering made of confounding the two aspects of the experimentation there clearly distinguished from each other.

Lehigh University, March 16.   Joseph W. Richards.

The Opening of the Chemists' Building.

On a fine crisp spring day, full of glorious sunshine, in the presence of representatives of chemical science and industry, assembled from many parts of this country, the new Chemists' Building at 50-54 East Forty-first Street, New York City, was formally dedicated on the afternoon of March 17.

The building and equipment has been described in our issue of last December (vol. VIII, page 701). The purpose for which it was erected and the ideals which it represents are admirably stated in the opening address of Dr. Morris Loeb to whom more than any other individual the thanks of the profession are due for the transformation of the idealistic conception of a Chemists' Building into an actual and beautiful reality.

Dedication Exercises

Dr. MORRIS LOEB, as president of the Chemists' Building Company, made the following address:

"I rise to welcome you on behalf of the directors and stock-

MORRIS LOEB

holders of the Chemists' Building Company and to thank you for the interest which your presence indicates in the formal opening of a building which we believe to be the first of its kind, not only in this country, but on earth. It is true that Berlin possesses in the Hofmann-Haus a home for the German Chemical Society and that London owes to the munificence of the late Ludwig Mond its Faraday Laboratories for Chemical and Physical Research. But this new building in which you find yourselves is planned to serve under one roof the social, intellectual, and practical needs of the chemical profession not of New York alone, but of our whole beloved country.

"The means for its construction have been furnished by men, many of whom can expect to share to but a slight degree in the benefits of the Chemists' Club, which occupies so much of its floor space. These shareholders see in it the incarnation of some of the ideals that led them to the pursuit of chemistry, pure or applied, as their lifework.

"For, strange as it may seem to the layman, who has seen the ugliest blots on a landscape designated as chemical factories, who has sniffed with disgust a chemical odor, has been urged to believe that the chemist's shadow contaminates pure foods, and has been taught in school that alchemy spelled fraud

and sorcery, our science is one calculated to develop the ideal side of human nature, and the chemist, more perhaps than the votary of natural science or the devotee of the so-called humanities, is led to an intense interest in human development.

"Our science aspires not only to know, but also to do. On the one hand, it leads us to delve into the secrets of nature, in the minute atom as well as in the far distant stars, in the living cell as well as in the crystallized relics of the convulsions from which this earth was born; on the other, it leads us to apply this knowledge to the immediate needs of man, be it in safeguarding his health, in ministering to his material or esthtetic
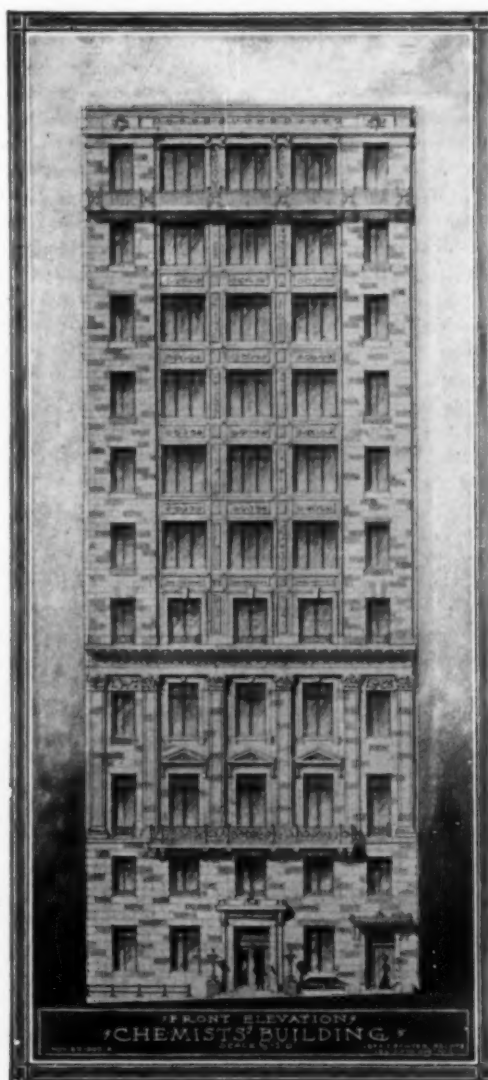
CHEMISTS' BUILDING

wants or in regulating his commerce and in facilitating his utilization of the earth's resources. These many points of contact with nature and with human interest will be the theme of the eminent men whom I shall have the privilege of introducing this afternoon and will be illustrated at greater length in the scientific meetings which are to follow; it is enough that we recognize at this moment that this versatility of method and of purpose must necessarily enlarge the viewpoint of the chemist, and to seek therein the motives for the ready cooperation in the present enterprise.

"Our shareholders content themselves with a moderate return for their money and have agreed that surplus profits shall accure to the benefit of chemical science. They hope that the facilities afforded within these walls will redound to the benefit of mankind and the prosperity of the country.

"May I emphasize the word 'facilities'? There are two ways

of aiding a man or a cause: by addition to the income or reduction of the expense. The pecuniary result to the beneficiary may be the same, but the moral one is far different; it is not only the beggar who is pauperized by the cash gift and uplifted by the aid which enables him to earn his own livelihood. Arts and sciences may be stimulated by prizes and scholarships beyond a doubt, but the relation between donor and recipient is not free from restraint, and the probability of human error in the selection of the right incumbent makes the method a wasteful one at best.

"Far better is it to remove those obstacles which hamper all work equally and are felt more severely by those whose means are restricted and who have not yet earned the recognition of the world at large. The laboratory student is encumbered by certain restrictions in America more than elsewhere. The higher price of commodities affects him in many ways besides the higher cost of living, rent of laboratory, installation of equipment, purchase of supplies, salary of assistant, acquisition of books. The advanced cost of labor militates against the construction of certain grades of apparatus and the preparation of the rarer chemicals in this country; and a curiously unscientific tariff law, while pretending to lift the duty from articles required for educational purposes, practically forces the colleges to make their purchases abroad and prevents American dealers from carrying an adequate selection of imported material. It is no exaggeration to state that this duty-free importation clause, as interpreted by the United States Treasury Department, forces the American chemist to wait from two to three months before making an experiment for which he could obtain his material in two or three days if he were working abroad.

"To remove these disadvantages in time and cost, to provide easy access to books and apparatus, to make room for the independent scientific worker are the ideals which hovered before the eyes of those who planned this present enterprise. Time will show whether they can all be realized, but whatever is done in this beautiful building, which we are about to dedicate, must open free opportunities to all and show favoritism toward none if the trust imposed upon its management be administered in the spirit of those who have contributed toward its erection.

"A library of the highest scientific importance and a museum of chemical substances will be available for every reputable chemist; laboratories for temporary as well as permanent use will be at the disposal of the earnest student; help and advice will be extended to the struggling beginner; good comradeship and hearty co-operation will characterize the Chemists' Club, and this auditorium, soon to be named after the first great chemist of American birth, will ever minister to his ideal of the application of science to the useful arts."

Dr. Loeb concluded with words of appreciation for the work of Messrs. York & Sawyer, the architects, of Mr. Ralph C. Crow and his associates in the construction company, of Messrs. Marks & Woodwell, the consulting engineers and of Mr. Chas. Eidlitz and Messrs. Black & Boyd, the contractors for the electrical and lighting equipment. "And now, ladies and gentlemen, I have given you an account of the empty shell. The spirit which is to animate it will be brought to your minds by the speakers whom I have the privilege to introduce—master minds of our science and guides of the future of its leading organizations."

Dr. Loeb was followed by Dr. Edward S. Morley, who spoke as the honorary president of the Eighth International Congress of Applied Chemistry, to be held in September, 1912, in this country. While the organization of the congress so far consists of officers only and no crew, yet the congress rejoices in the opening of the Chemists' Building, which will be its headquarters, and the congress transmits its hearty congratulations.

Prof. Alexander Smith spoke as president of the American Chemical Society on research work. Two requirements are absolutely necessary in an investigator—first, a proper training,

and, second, a true spirit of research or thirst of discovery. Both belong together. Professor Smith explained how the Chemical Society had helped possible investigators to find themselves and expressed the conviction that the new Chemists' Club Building would offer magnificent opportunities in the same direction.

A letter from Prof. Ira Remsen, president of Johns Hopkins University, was read, expressing his regrets of being forced to be absent. As past president of the Society of Chemical Industry Prof. Remsen referred to the relations between science and industry.

A letter from Prof. Edgar F. Smith, provost of the University of Pennsylvania, also expressed the writer's sincere regrets of not being able to be present.

Prof. William H. Walker, of the Massachusetts Institute, then spoke as president of the American Electrochemical Society. The field of chemical science is now so large that no one person can expect to cultivate more than a small portion of it. Electrochemistry deals with the chemical changes brought about through the application of electrical energy, and within this limitation has grown up a strong, virile organization, international in its scope, the American Electrochemical Society.

But, as Dr. Walker pointed out, "the specialization of to-day tends to carry us apart—tends to a divergence of interest. This new chemists' building will function as a center to which every chemist, however diverse his interest, will be drawn. There was a time when the advice to a young man was 'Paddle your own canoe.' Each chemist did this to so great an extent that he worked for himself, by himself, without thought of others. The national chemical societies have already done a grand, good work in bringing men engaged in chemistry together, but this Chemists' Building will be an additional and most potent factor in placing the profession of chemistry where it by right of its importance belongs. No longer will the cry be 'Paddle your own canoe,' but, rather, 'Get the stroke and pull together.' It is this sentiment which is exemplified in the Chemists' Building. Here we can present a united front, and strive for the further uplift of the chemical profession and the community."

To Dr. Loeb and the men who have stood by him Professor Walker tendered the grateful thanks of the American Electrochemical Society. "And again I would greet the Chemists' Club, and wish for it many long years of usefulness in which to enjoy the splendid new building which to-day is theirs."

Prof. Wilder D. Bancroft, of Cornell University, then presented in his characteristic humorous manner a brief yet suggestive address on chemical education. He said that the trend of the many discussions in recent years had been how to teach a man so that he becomes a technical chemist, so that he knows all about machinery, about the handling of materials on a large and small scale, about the handling of men, about questions of costs, etc.

All these, Professor Bancroft said, are valuable and interesting problems. But people who want to instruct students in these subjects overlook several very important points. Firstly, that it would require a prohibitive expenditure of time. Secondly, by giving a man a proper drill, can you really make him a works manager? Why is a works manager paid a big salary? Because he is relied upon to pull the plant out of unforeseen difficulties. An ideal plant, running with mathematical accuracy, would not need a manager.

Professor Bancroft thinks there is something wrong with our methods of education, but he finds the trouble to be rather in another direction. Every young boy asks in a few minutes a great many more times "why"? than his parents can ever answer. But when the same boy has passed ten years through a school and four years through a university he no longer asks "why"? Why this is so—this would be a good subject of future discussions tending toward an improvement in chemical education.

Then followed the unveiling of the tablet of Count Rumford, after whom, as the first great American chemist, the Auditorium is named. Dr. FRANK W. CLARKE, of the United States Geological Survey, gave a very witty history of Count Rumford's life. He spoke of Rumford as one of the real great Americans and dwelt on his statesmanship. He emphasized that Rumford, an American, founded the Royal Institution in London. Yet his greatest discovery was Humphry Davy, and the latter discovered Faraday.

Dr. Loeb then explained the building, its design and equipment, and handed the keys of the clubrooms of the Chemists' Club over to its president, Dr. RUSSELL W. MOORE, who replied in a felicitous little speech.

This concluded the formal dedication exercises, which were followed by a reception in the clubrooms.

Scientific Sessions and Banquet.

The evening of Friday, March 17, and the morning and afternoon of Saturday, March 18, were devoted to scientific sessions held under the auspices of the New York sections of the national chemical societies.

The meeting of the New York section of the *American Chemical Society* began with an elaborate historical and philosophical address by the chairman, Prof. CHARLES BASKERVILLE, of the College of the City of New York.

Prof. JACQUES LOEB, of the Rockefeller Institute for Medical Research, followed with a suggestive lecture on the characteristics of living matter from the physico-chemical point of view.

Prof. R. B. MOORE, of Butler College, Indianapolis, gave a lecture on the rare gases of the atmosphere. The lecture was illustrated by a series of highly interesting experiments, in which the lecturer isolated with great skill and success the rare gases from atmospheric air.

While the session of the American Chemical Society was thus pitched in a highly scientific key, the proceedings of the other two societies on the next day broadened in their effects, bringing out the human not less than the technical and scientific sides of engineering.

The session of the New York section of the *American Electrochemical Society* started with an address of the chairman, Mr. ELMER A. SPERRY, who emphasized that of all branches of applied chemistry electrochemistry is most specifically American.

Dr. W. R. WHITNEY, chief of the Research Laboratory of the General Electric Company, followed with a lecture on "mental catalysis." This admirable and inspiring address on idealism in science and engineering is printed in full at the conclusion of this report.

Prof. WILDER D. BANCROFT then lectured in a very interesting manner on the chemistry of phosphorescence, showing how it is possible to distinguish the chemical reactions which play a part in phosphorescence. After the subject of phosphorescence has been studied in great detail from a purely physical point of view, Dr. Bancroft's way of looking at it from the chemist's standpoint is decidedly novel and promises important results.

The session of the New York section of the *Society of Chemical Industry* in the afternoon began with an interesting address by the chairman, Dr. CHARLES F. McKENNA, who in conclusion read a letter from Hon. James Bryce expressing his regrets of not being able to be with the society on this occasion.

Prof. WM. P. MASON, of the Rensselaer Polytechnic Institute, followed with a very instructive address on the contributions of chemistry to sanitation, especially water purification.

The session was concluded by an address of the doyen of the chemical professions in the United States, Prof. CHAS. F. CHANDLER, who gave interesting personal reminiscences of the history of chemistry in New York City.

As in classic Greece a serious dramatic trilogy was always followed by a satyrplay, thus the trilogy of serious scientific sessions was followed on Saturday night by the first banquet of the Chemists' Club in the new building.

It was a decided success, in spite of the fact that it was almost too well attended. Frolicsome merriment reigned supreme, and the toastmaster, President Russell W. Moore, and the master of the revels, Mr. Elwood Hendrick, must be highly complimented on their success. Dr. Moore's chief speech was in the presentation of a large silver loving cup to Dr. Loeb—as Dr. Chandler said, only a token of our affection, not a measure. Mr. Hendrick contributed delightful newspaper stories and remarkable telegrams and letters.

Other speakers were Dr. Loeb, Dr. Schweitzer, Dr. McKenna, Mr. Plaut, Prof. Alexander Smith, Dr. Rosengarten, Mr. Parker, Dr. Chandler and Mr. Jacob Hasslacher, whose concluding words were that while the English language had no exact equivalent for the German Gemütlichkeit, the Chemists' Club was the nearest he could think of.

The celebration was fittingly concluded by a concert of the Olive Mead Quartet, on Sunday afternoon, with a program of Mozart, Tschaikowsky, Mendelssohn, and Grieg.

* * *

Mental Catalysis.*

BY DR. W. R. WHITNEY.

Perhaps you have asked yourself the question, what has this subject of mental catalysis to do with electrochemistry? Therefore, I want to explain.

One might justly expect from me at this time a paper embodying the results of some specific electrochemical research, but when I was asked by your committee to prepare a paper my first impulse was to go back to first principles, and as the title had to be given before the paper was started, I chose a title which might cover a line of thought along which I had already quietly enjoyed some study. You know that in most extended chemical researches a great deal depends on a study of what in Germany we called our "Ausgangsmaterial." A long line of interconnected reactions, of properties and of products are evolved from a certain "Ausgangsmaterial," and we are probably all familiar with the way in which this whole line may be altered by only a small change in the purity of our "Ausgangsmaterial." So, for our science in general, I am going back a few minutes to consider our Ausgangsmaterial.

I suppose that every chemist who is deeply interested in his work finds himself sometimes wondering: Am I doing this in the biggest way, or am I a small machine, working only with my hands? Perhaps I am only a little more complex machine, using a stock of knowledge and certain trained habits merely as a means of livelihood, just as some engine uses steam and eccentrics. Or, finally, is it possible to be what is called a free moral agent, using knowledge, training, talents, and all to their ideal efficiency?

Those of you who have read Maeterlinck's "Life of the Bee" know that it seems as though the bee-hive represented the acme of communistic perfection. Yet we are apparently more highly endowed than bees, and much more is expected of us There seems to be something in us which calls for a continually widening horizon. We must do more than work.

This is an attempt to consider for a moment some of the laws of forces which may underlie successful work and advances in its broad, its only satisfying sense. Of course there are such forces and such laws. We all feel the force of a great, far-seeing mind. We can easily point to our leaders of the past. Our history itself is largely the product of time into some mental forces. I want to imagine that the force which determines advance in any line is *idealism*, and I call it the catalyser. I want to point out that this force in its growth is subject to two entirely different influences, which may be looked into and studied separately. These I may call the *conceptive* and *receptive*. In each of these we all take part. A

club like this is a place where both the conceptive and receptive influences should be very prevalent.

A number of years ago I overheard a statement which was not intended as complimentary, in which a young chemist was referred to as an idealist. I think the intention of the speaker was to use the word as an antonym of the word "practical." This has often been recalled to my mind, and the results of some thinking on the subject form the matter of this brief talk on Metal Catalysis.

There is no profession where idealism can play a more important part than in our own. Why? Well, because we possess all the elements for material realizations. The exact bearing of idealism is fairly clear to me, and I want to make it clear to you.

A methodical chemist who is solely trained to observe and to record may *enormously contribute* to the science without *advancing* it appreciably. By advance, I mean to infer an increase in our breadth of horizon. I may be faithful, industrious and well educated, and contribute largely to the work of my subject, but there is something which will tell more certainly upon my relation to my work than my erudition. I think this criterion is idealism.

Far be it from me to compare the work of one kind of chemist with that of another, for until we shall have learned just exactly *why* and how we are, we are not in a logical position to compare one another's contributions. I rather want to interest you for a few minutes in the peculiar *attractiveness* of idealism.

"But is this a real thing? Is it practical"? I hear you ask. I answer, "It is as real as we are." Consider its growth. It is safe to assume that our earliest ancestors were gifted with as much as or more physical strength than we are. As organic entities, apparently tending to increase the entropy of the universe, they did not differ much from ourselves. In the stone age a dietetic study would have shown nearly the present calorific change and metabolism. I do not mean to raise the question whether we are better than they or not, though that should be permitted to an idealist. But I expect you to admit that we are different and are growing more so every day.

Our horizon is broader. Now I want to point out that it is our idealism that accounts for the difference. I call idealism that developed power of *prevision* of the more perfect, that mental elasticity which sees improved things before they arrive, which may even see some that never arrive, and which power has hope and optimism for pressure indicators. This is the catalyser.

The doctors of medicine and the specialists in diseases have shown us how, under certain conditions, contagions appear and spread; how they are carried from one plant or animal to another, under what conditions they thrive and how specific immunity may be procured. Such discoveries (relating to the realities of life) apply directly to the ideals. It can be seen in the histories of our mental growth. For example, the spores of plastic art were evinced in the stone age, but the idealism did not develop very rapidly until much later. But we find it almost as widespread and advanced in Egyptian and Greek sculpture before the time of Christ as it is to-day. There was a period and a place in which it made most rapid strides.

Idealism, as expressed in marble, which first had mental form in the minds of a few idealists, spread by their contact with others and soon reached a splendid state of advancement. Many centuries later idealists from Giotto, de Vinci, Michael Angelo and the painters of the fifteenth century spread the idealism of painting so that in their eras the world very rapidly made its greatest advances in painting and in architectural art.

We are so accustomed to the laws governing idealism that we often fail to realize them. A few idealists partly realized their visions in some such ways, and world-advances were made. That is, permanent additions were made to the diameter of the world's mental horizon. Through all these epochs the

realist lived. The cost of food, expressed in labor, remained about the same. The question whether a purely mental enjoyment was a utility had long been put, and answered as now. Among the things which kept on acting was idealism.

In the chemist's field we see the value of idealism in matters both small and large. Usually the first expression of an ideal is so unrealistic as to meet opposition or at least friction. I think we can consider some of our hypotheses as ideals. Consider for a moment the benzene ring. We all know its value to us as an idea, but it was once an ideal. The even more idealistic theories of disease immunity, such as that proposed by Paul Ehrlich, with its fantastic receptors and side chains, while leading to very important practical results, still appeal to many as too speculative, too idealistic. But they are more than valuable. They hasten our advance, they catalyse.

I do not care to raise the question of the exact accuracy of the conceptions of the idealist. This we need never know. But as trees are known by their fruits, we should measure the value to us of idealism by the products. We may admit that what idealism accomplishes for us might be reached in time without it. This is the earmark of a catalyser. In catalysis the velocity of a reaction is increased by agents which still exist, unaltered, after the reaction. In many cases the catalysis is plainly one of contact. I have known several men who worked in Edison's laboratory. They are still a definite type of idealist.

I also recall how, just nine years ago, a small group of 11 men actuated by an ideal in the mind of two or three started in Philadelphia the American Electrochemical Society. My reason for referring to it is to point out that it was a *lonesome mental conception* before it became a group of men. I am trying to point out the value of such ideas and their fertilization. I want you to realize their frequent frailty, their need of nurture and their final possible power.

I find an application in this occasion to-day. An epoch-making event is just transpiring. In nearly the largest city in the world the first clubhouse and guild hall devoted to our science is being inaugurated. It was first an ideal, a vision in the mind of a single man. He could have slighted it. He could have said to himself: "We have always gotten along without this thing. Why disturb the equilibrium of the day?" But he persisted, and started a thread of history which will never break. The ideal preceded the real, the mental vision preceded the physical vision. That is the law. The ideal catalised the reaction and we have the product. This clubhouse will do much for idealism, and all I can do now is to point out ways along which it will be done.

The deep student of chemistry, confined entirely to his books and laboratory, has ideals, but contact with others of his calling will contribute enormously to his information and incentives and must, therefore, direct and influence his ideals. This is so well known as to need no enlargement.

The teacher to whom we owe so much and on whom such a great responsibility rests can be aided, through this organization, with increased efficiency. Here he will come into contact with others of his profession and can gain from them encouragement for his ideals. He will also learn of the ideals and advances of the industries and increase his power of imparting ideals to his students.

As I still count myself among the teachers of chemistry and am so counted in Institute catalogs I may be permitted to say that in the teaching of science there is still very much room for improvement. I would go further and say that we have scarcely learned how to teach idealism *at all* and that we are continually in danger of destroying what idealism comes under our observation by the very methods of this system we employ. Most teachers have probably had occasion to notice the loss of what he calls enthusiasm in some student as the latter has been taught more. Of course, his enthusiasm and optimism ought always to grow greater with added powers instead of becoming less.

One thing needed by us as Americans is more idealism. In our times, I think I am safe in saying, idealism is not greatly influenced by climatic conditions, but it certainly is by environment. I don't thnk there is proportionally as much idealism in the English as in the French or German of to-day. I know more about us Americans. We are generally defective in this respect. We are aggressive. We are realists and often, basing our energies upon foreign visions, we can do the rest. This is most marked in the industries, and we know it well in physics and chemistry; but in art and literature we are still copyists. In medicine and surgery we show to better advantage, though I think most of the pioneer conceptions are still of foreign make.

In other words, I believe we have, as Americans, plenty of latent energy, but are still deficient in idealism. We can and do master the problems with which we come into contact, but largely for themselves and possibly for the pleasure of doing something useful. This alone may be commendable, but it can be improved.

A would-be idealist cannot be expected to produce useful ideals if he is out of contact with his fellow-man. We need the idealist as a guide, but a guide who is so far ahead as to be out of sight is a poor guide. This means that the contact catalyser must really be in contact to catalyse.

Huxley, in an address as the rector at Aberdeen, says: "The man who is all morality and intellect, although he may be good and even great, is, after all, only half a man. There is beauty in the moral world and in the intellectual world, but there is also beauty which is neither moral nor intellectual—the beauty of the world of art. There are men who are devoid of the power of seeing it, as there are men born deaf and blind, and the loss of those, as of these, is simply infinite. There are others in whom it is an overpowering passion, happy men born with the productive (or at the lowest) the appreciative genius of the artist. But in the mass of mankind the aesthetic faculty, like the reasoning power and the moral sense, needs to be roused, directed and cultivated."

I consider idealism a name for this faculty to which he refers. It is the faculty of seeing beyond and over the physical dimensions of things. It is the power of being the parent of plans. It is that something which makes us call certain men artists in their profession.

The start we all get in the physical sciences by being taught in laboratories especially equipped to insure contact of student with the thing, rather than with the book or with the man, is an idealism realized in our own day. It was only a vision seen by a few physicists less than a hundred years ago, and this led to chemical and physical laboratories equipped to give experimental work to students. I only mention this to show how we are realizing the benefits of a condition which a short time ago was only an idealistic dream.

I am quite sure that within the lifetime of some of us here he would have been smilingly and pityingly called an idealist who had dared predict an 11-story building for a chemists' *club*. It seems realistic enough to us now, but half a century ago there were hardly chemists enough in the country to keep a chemical society alive, and they fined themselves for absences from meetings, too. Such advances are not exactly like "Topsy" in "Uncle Tom's Cabin." They don't just grow. They can be traced to some ideal in every case.

In a hearing before the Massachusetts Legislature the other day, Mr. F. P. Fish, formerly president of the Bell Telephone Company, made the following remarks, which are idealistic, but warranted, and are of interest to us:

"I should like to prophesy that we are really just at the beginning of this industrial development. During the last generation we have seen the extraordinary development of electricity, which is not by any manner of means completed. I am satisfied that during the next generation—the next two generations—there is going to be a development in chemistry which will far surpass in its importance and value to the human race that of electricity in the last few years. A development in chemistry which is going to revolutionize methods of manufacture, and, more than that, going to revolutionize methods of agriculture. I personally believe that in a generation or two we shall see the deserted farms of New England, if there are any, blooming with vegetation because of the work that is done by chemists. * * *"

Idealism? Certainly, but practical to the core. Why? Because it helps produce. It catalyses. This spirit is almost invaluable in assisting in realization. Bare mechanical work in any field is a heartless thing. Its tendency is to habit and unaltering self-perpetuation, but the idealist interferes and keeps pointing to something more perfect, more interesting.

Henry Van Dyke, in writing on creative education, said: "The right ideal of education in a democracy is the creative ideal. It does not seek to adorn men with certain rare accomplishments which shall be the marks of a Braminical caste. It does not seek to train men for certain practical pursuits with an eye single to their own advantage. It seeks, by a vital culture, to create new men and new kinds of men who shall be of ever-increasing worth to the republic and to mankind." And, again: "It has four definite marks: the power to see clearly, the power to imagine vividly, the power to think independently and the power to will nobly. These are the objects that the creative ideal sets before us."

Herbert Spencer also saw the operation of idealism when he said that society was a growth and not a manufacture and has its laws of evolution. He says: "Our immense manufacturing system, with its multitudinous inventions supplying both home and foreign consumers, * * * have been naturally and not artificially originated. * * * Knowledge developing into science (which has become so vast in mass that no one can grasp a tithe of it and which now guides productive activities at large) has resulted from the working of individuals prompted not by the ruling agency, but by their own inclinations." It is the direction given to these inclinations that determines idealism. This is a flexible factor. It depends upon us in both the efferent and afferent, our production of ideals and our reception of them.

One can hardly look into the history of any leader of a profession without seeing the effect of idealism, and yet we are more apt to think first of the individual's accumulated knowledge or his products. Think, for a moment, of the idealism of a Faraday. It is really more to be admired than his tangible work. It continues to operate long after he has passed away. The way he undertook his work we call ideal. Everyone admires his approach to his subject, his deference. The ions he idealized we know by name and by weight. The lines of the magnetic field, which were an ideal to him, have the bearing of working realities to us to-day.

I did not start with the thought that I would be able to perfectly declare the genesis of idealism, or mental catalysis, any more than I might explain chemical catalysis. But just as we know a few of the laws governing the latter, so we may cite a few principles of the former. Idealism grows better in a warm, receptive atmosphere than in a chilly or doubtful one. In other words, while I do not claim at this point that idealism can be made autogenetic or that one can will himself an idealist, I know that one may increase the fertility of the soil in which the plant grows.

I cannot help thinking at this moment of the late S. P. Langley, of the Smithsonian Institute. As an American citizen I am ashamed of myself at the mention of his name. He was called an idealist. One of his ideals had to do with aeronautics. I believe he did more to advance the knowledge of the subject than anyone prior to his day. He did not capitalize his idealism, either. He built a machine which was almost identical with our present successful types, and it flew half a mile under its own power. It was as healthy a set of experiments as we American people have ever paid for, but because his ideals were not completely realized in the first test we laughed

him to death. We may know enough as a practical people, our morals may accord with any standard erected, but our appreciation of idealism needs a lot of fertilizer.

It is in such a place as this club that idealism in chemistry will be fostered. The atmosphere can be made to favor its growth. Instead of shunning some idealist as a crank (and the pet of his idealism as a freak) we can show him we have learned that most essentially new things have been called freaks ever since the word was known. What is better, perhaps, we can learn that it greatly helps in the realization of ideals to assist them.

We recognize the effect of idealism when we see it in such art as that of Michael Angelo. We see, too, that there must have been a great deal of idealism back of the wingless Victory of the Acropolis or the winged Victory of Samothrace, because even now they are perfect to us, but we ought also to find it nearer home. We say it is in poetry, but it may also lie in prose. If it belongs to art, it also belongs to science. If it has existed, it still exists. Perhaps the law of conservation may be applied to it, as it is to mass and energy.

It certainly does not grow as a result of mere work, however hard. It is not measured in watt-hours or foot-pounds. It cannot be forced. Dr. Gulick has said: "Compulsion fails to account for the greatest things in the world. One cannot imagine, for example, that those poems which bless us with their beauty and strength, with their vision and inspiration, were written under a compelling sense of duty. Such poems as Mrs. Browning's "Portuguese Sonnets" spring from sources other than those of necessity. It is so with the world's great statues. There was a vision of beauty, an ideal within the souls of the men who made them, and this ideal was so compelling that they worked it out, oftentimes at great personal sacrifice." He also says, "When we say to a man, 'Play the game,' we mean treat the situation as an ideal." It means to drop all selfish individual considerations and to meet the real situation by ideal means.

There are times when the most of us feel that we know more about mental paralysis than about mental catalysis. At the end of a day's work, when the practical difficulties seem to have been particularly devised and peculiarly adapted to meet our special insufficiencies, we are apt to feel ourselves far removed from the ideal of anything. A clubhouse such as this ought to help dispel such feelings. When we are unable to bring forth pet flowers of idealism for the sake of the fertilization that others can give them, we can at least carry a little watering-pot for the opening bud of some other fellow, and that's a use for a club.

Research Laboratory,
General Electric Company.

The Arizona Copper Company has issued its annual report for the year ending Sept. 30, 1910. During the year 599,-250 dry tons of sulphide ore were concentrated, the ratio of concentration being 5.14 to 1. Improvements are under way which will result in combining the No. 5 concentrator into the No. 6, greatly enlarging the capacity of the latter and permitting the treatment of a lower grade of ore than formerly. It is expected that the changes will be completed by the middle of this year. The oxide concentrator treated 115,223 dry tons of ore and leached 102,381 dry tons of tailings. The copper recovered amounted to 11.3 per cent of the total copper produced during the year. The sulphuric acid plant produced 2971.5 tons of acid. In the smelting department an average of 3.8 furnaces were in blast, smelting ore and concentrate amounting to 158,532 tons. The average yield of copper from this material was 10.14 per cent. The company has been carrying on extensive experiments in metallurgical treatment, which will be of benefit in future changes or improvements in the plant. The output of copper for February, 1911, was 1430 tons.

The Evolution of Portland Cement Processes.*

By Charles F. McKenna, Ph.D.

In the Portland cement industry there is a perpetual but healthy unrest. No sooner is one feature of marked improvement successfully brought forward producing a suggestion of finality than several minor progessive steps are seen to tend together toward such economic advantages as to constitute practically again a new process. On reviewing the subject I have felt that the history has the elements of a romance, if it were not for the overpowering newness of it all, and I have felt that the near future still has surprises in store.

I hope I may leave this impression upon you, and also in rehearsing it to show properly that while praise is due to the mechanical engineer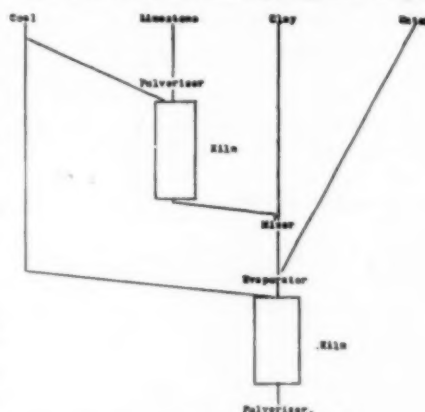, it must also be given to the chemist. Indeed, it is generally felt to-day that it is to chemical engineering that the industry must appeal most strongly in the future, and that progress and economy is promised more surely because the leaders have realized that the trained and experienced chemical engineer is best fitted to cope with the new problems and avoid some errors similar to those of the past.

FIG. 1.—ASPDIN PATENT, 1824.

We have seen a product obtained in a most primitive fashion only 50 years ago now produced throughout the world in millions of tons annually, and with such economy that for 1 cent 12 lb. of raw material will be taken from the earth, dried, ground, calcined and vitrified, and the product ground again. It would seem as if the use of fuel, machinery, human hands and human brains could not go further. Yet there is ample scope for improvement and economies as you will easily perceive.

Aspdin's invention seemed a simple one (Fig. 1). He pulverized limestone, burned it, mixed clay with it and water to a plastic mass, after which this was dried and burned in a kiln and the product pulverized.

FIG. 2.—OLD ENGLISH PROCESS.

Much experimenting had previously been done by himself and by many engineers throughout the world to try to discover the cause for hydraulicity, but beyond perceiving the value of the argillaceous elements in the limestone, none of them discerned the important part played by high temperatures in the burning. Aspdin was the first to combine these elements properly, and burn much of it properly.

It is very probable that he did not know that the vitrified pieces of his clinker made the only true Portland cement, and it is also very probable that other experimenters had obtained vitrified Portland clinker when burning natural argillaceous

limestone and did not recognize its special value at the time.

The success of Aspdin's work was noted in other countrys, but for the first 25 years its greatest vogue was in England. Many modifications had in the mean time been introduced there and the typical English process of the day was one (Fig. 2) in which chalk and clay were introduced with an excess of water into wash mills—large circular basins with revolving harr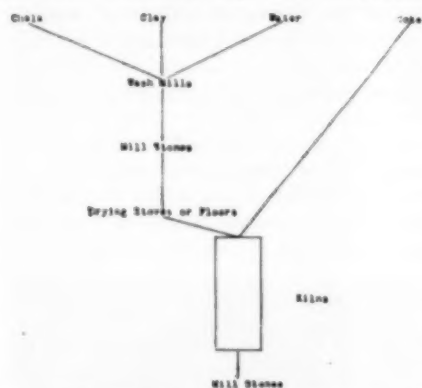ows—and after incorporating here, transferred to large backs or settling reservoirs from which the surplus water was drawn off. It took about six weeks to settle.

FIG. 3.—LATER ENGLISH AND CONTINENTAL PROCESS, SEMI-WET, AFTER 1870.

The stiff mud from these was dried on floors heated from below and then charged into the kilns in which coke or coke dust was the fuel. The product was ground by burr stones.

The juxtaposition of chalk deposits near the Thames and the Medway and the mud banks of these rivers, together with a plentiful supply of coke from the gas works of London caused a large development of this industry near the world's greatest city.

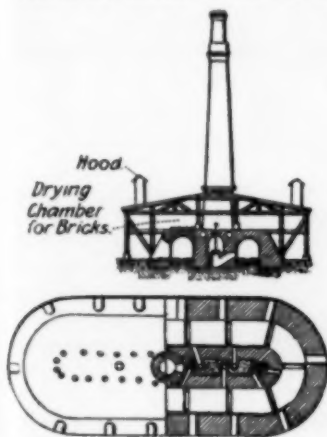About the middle of the last century the industry was fairly started in Germany, and was destined there to take a development characteristic of that country, and in it the skill of the chemist was successfully given free scope.

FIG. 4.—HOFFMAN CONTINUOUS KILN.

The favorite method ultimately developing in Europe (Fig. 3), sometimes called the semi-wet process, was one in which less water was used in the beginning, and in which air incorporating mill was used on the stiff mixture. This saved the time previously allowed for the very wet mixture to settle in the backs.

When you add good chemical control of the original proportions and this feature of incorporation by grinding you see how progress was being made. This is what the Germans particularly did.

The kilns first used were the ordinary lime kilns, later increased in height for the purpose of increasing the heat.

Later in some of the greatest of the German works the Hoffman continuous kiln (Fig. 4) was much used in which compartments are charged and discharged and the flat roof used for drying.

In Germany the Dietzsch became the favorite in later years. In this kiln (Fig. 5) the material is preheated in the upper part as usual, and in the central part into which it is drawn by the workmen operating through the fire door it is particularly exposed to high heat by reason of the construction of the furnace here. The clinker gradually cools as it sinks below.

The Schöfer or Aalborg kiln is an upright one like the Dietzsch and has a zone of high heat.

Now investigators in this country in the decade after the close of the Civil War noting that the Portland cement imported from Germany and England was selling for $5 a barrel sought eagerly for materials from which to make it.

It was thought that a soft chalk must be found before any economical works could be thought of. This was the view of all English cement makers who were visiting this country at one time with a view of starting business.

But David F. Saylor, who was making natural cement from one kind of rock at Siegfried's Bridge, near Allentown, Pa., began experimenting in the early seventies upon a mixture of this rock with a purer limestone. He produced in effect a true Portland cement (Fig. 6) and he was destined to be the first in
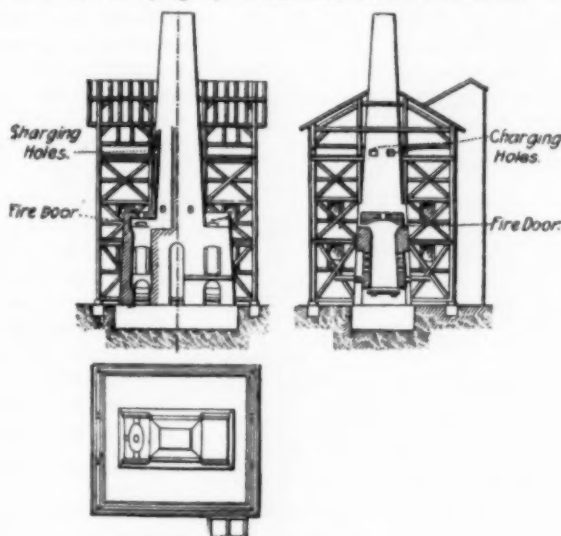
FIG. 5.—DIETZSCH KILN.

a long line of American inventors, each of whom can be said to have modified the industry so fundamentally and markedly as to the world in each step forward.

The first kiln used to produce Portland cement in America was a bottle kiln of the type used in England. Subsequently at Coplay, Pa., the seat of the industry, the Schofer kiln was built.

Saylor's American Portland was the recognized and only important American Portland cement for a few years after this till Antonio Navarro, a capitalist, entered the business. Ransome had patented a rotary kiln in England in the seventies, but it was not practically adopted there. In the early eighties Navarro secured the American rights, and what is now the present Atlas Portland Cement
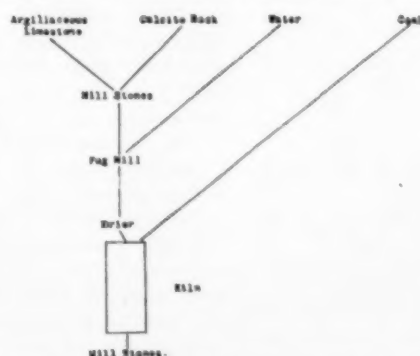
FIG. 6.—FIRST AMERICAN PROCESS. (SAYLOR, ABOUT 1875.)

Company was started at Northampton, Pa. Whittaker also used a similar kiln, and both of these used oil as a fuel.

This was entirely a dry process (Fig. 7). It is sometimes thought that in no country but America was it the practice in those days to eliminate the wash mill and to incoroporate dry. This is not so; for in Europe from 1885 to 1895 there were several plants operating on the process of: First, crushing and pulverizing dry; second, mixing and moistening with about 15 per cent. water; third, moulding into bricks; fourth, burning; fifth, grinding clinker.

In 1895 Hurry and Seaman were amongst the first to operate

in this country by a process which was destined to be of great influence the world over in the industry. This was the process for using as the fuel powdered coal blown into the kilns. The product was so well burned and so much in volume was continuously produced that the method rapidly extended. The clinker thus produced made a cement which was very quick setting. If a change of the composition of the raw materials was made to avoid this the cement was unsound, particularly upon trial by the quick method of being exposed to boiling water or steam. Then it became the custom to do here what had for some time been practiced in Europe, namely, to add plaster of Paris or fine ground gypsum to the extent of 1½ per cent. to 2 per cent. to the ground cement, which modified this phenomenon materially (Fig. 8) and produced a hydraulic substance of very desirable qualities. A little later, almost within the last twelve years, it was discovered that the raw materials must be very finely ground if you want to succeed in getting a perfect clinkering.

FIG. 7.—EARLY AMERICAN DRY PROCESS (ABOUT 1890.)

The wet method of the European works did good incorporating, and if you want that in the dry process and the quick-acting rotary kiln you must grind to an exceedingly great fineness. Also, if the cement is coarse it will hydrate slowly, with disastrous results of expansion. This was the heyday of the mechanical engineer.

These details of fine grinding had been neglected by the European practitioners of the art, but really explained their troubles. Their raw materials had been all right, because they h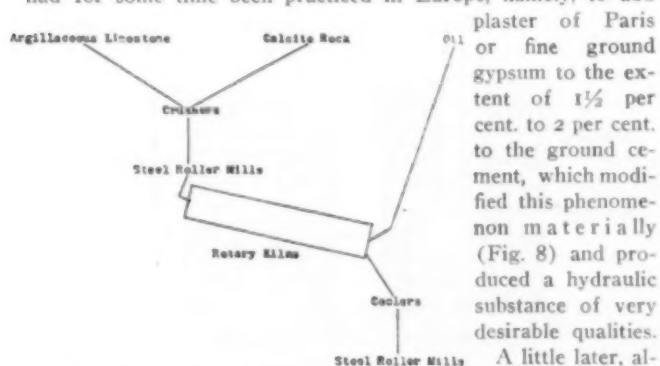ad chalk and clay and it facilitated wet grinding. The incorporation was good, and the clinkering consequently was good, but their cement was frequently bad because it was coarse. Immediately a great variety of milling apparatus was invented and the American mechanical engineers worked hard upon this problem and with great success, and really the
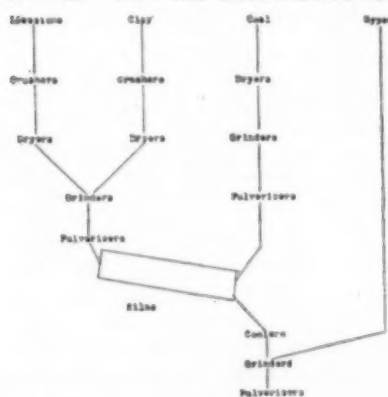

FIG. 8.—MODERN WORLD-WIDE PROCESS, DRY MATERIAL.

inventing and improving of this class of apparatus is still going on. The one kind of mill, modified, will serve for both raw and clinker grinding.

Two important classes of milling apparatus have been brought into use in this industry.

The development of flour milling when away from stone mills was towards steel roller mills, but in the cement industry' the development of two important classes of comminuting apparatus resulted from the abandonment of stone mills. (It is true, stone mills are not yet entirely antiquated, for a new mill at Norfolk has just been equipped with everything of most modern form except the mills, which are burr-stones and which on experiment have proven to give satisfaction for the material operated on—marl—An interesting reversion!)

Of the new classes of mills referred to we have those of that type to which belong the Griffen, the Fuller and the Kent mills, in which revolving steel shoes or balls press against a steel die or channel. The Fuller, using balls, is highly efficient, particularly in producing a high percentage of the finest flour of cement.

The other type requires two separate installations, namely, a large drum lined with steel plates and partially filled with steel balls, to do the comminuting of rocks coming from the coarse grinders, and a long horizontal drum partly filled with large quartz balls, to do the pulverizing.

But the genius of Edison was now introduced upon the stage and in the first years of the century, after improving the large crushing machinery, he turned his attention to the improvement of the kilns. The prevailing length at this time was 60 ft., with an output of about 180 barrels per day and a
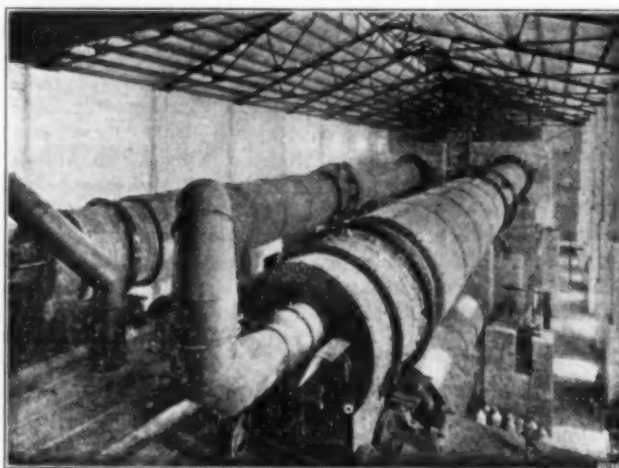
FIG. 8A.—ROTARY KILNS WITH ENLARGED BURNING ZONE AND COMPRESSED AIR FIRING AT THE WORKS OF NOERRESUNDBY PORTLAND CEMENT-FABRIK, NOERRESUNDBY, DENMARK.

coal consumption of 125 lb. per bbl. Some kilns 100 ft. long and 7 ft. diameter had been used in Europe on wet materials. Edison believed that if the kiln were 100 ft. long the product would be larger, the cement better and the coal consumption less. He has proven these points. But even with this economy the fuel consumption was three times the theoretical and twice what it should be practically. Immediately interest was centered upon the economics of fuel consumption in the Portland cement kiln.

It is admitted that the greatest avoidable loss is in the stack gases; next, the loss of radiation, and lastly, the heat carried off by the clinker. The last named has been most often attacked. Losses by radiation have been lately considered by inventors, but not yet successfully obviated, principally on account of the dilemma or choice between overheating the lining or overheating the shell. The losses in the stack gases have been diminished by careful attention to the details of burning, and lately it is believed by still further lengthening the kiln. One or two kilns here and some abroad, are said to be now operated experimentally on a length of 235 ft., more or less, but results are not divulged.

Strange to say, it is my belief that economies in coal, taken as a whole; that is, the coal for power and the coal for burning, will be improved by returning to the wet process. Before describing this I will speak of another process that marks an important epoch.

One of the greatest developments in Portland cement manufacture in this country has emanated from the steel works. Blast furnace slag, particularly when treated by water when hot, and then granulated, has many virtues for the alumino-silicate element in a hydraulic compound with lime. This was the old slag cement, but deserves no further mention in that

the composition and the reactions of that product are entirely different from Portland cement, belonging rather to the class puzzolana cement, with which Roman engineering accomplished much.

But investigators both here and abroad labored to produce clinker from a mixture of slag and limestone, and with the high heat of the rotary kiln they have been able to do it. It differs little from the standard process except that the slag is the clay element and is at once ready for pulverization, and except that Kent mills, together with air separators, are used for finishing. They have a thermal advantage, both in the fact that part of the lime has been calcined previous to their receiving it, and part of it is in favorable form of combination with the silica and alumina. Other advantages possessed by a steel works in making slag Portland cement are the credit

the same time, and really manufactured on a commercial scale, but one by one succumbed to the competition of the Lehigh Vallley material. The latest to close, the Empire at Warners, N. Y., was a very important factor for some years, producing a good cement in rotary kilns, but under severe economic difficulties. Michigan suffered most from the false hopes held out of profit from her marl beds.

Now, it would seem strange to admit that wet marl costs too much to dry or to put in the kiln in a slurry, and then to claim that grinding into a semi-wet mix hard and almost dry rock and clay, or rock and shale, is a good economical proposition. Yet the truth of this is coming to be recognized.

A company operating in one of the Eastern States built a wet plant for limestone and clay quite some years ago, and although their handicaps were great they have succeeded by
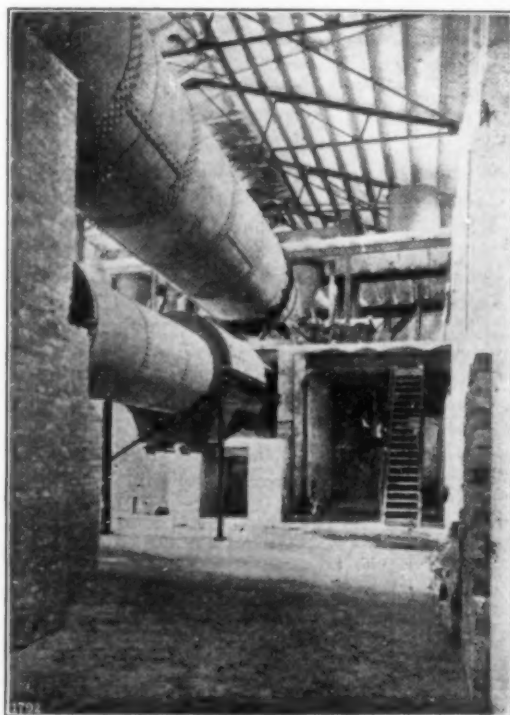

FIG. 8B.—ROTARY KILN OF NOERRESUNDBY PORTLAND CEMENT FABRIK, NOERRESUNDBY, DENMARK.

The Rotary Kilns are equipped with enlarged burning zone, compressed air firing and under coolers.

FIG. 9.—DIAGRAM OF MODERN CEMENT MANUFACTURE.

for removing what is otherwise a costly nuisance and the important advantage of having blast furnace gas to utilize for the production of power.

The manufacture of cement under these conditions is so favorable a proposition for the United States Steel Company that it is rapidly becoming the largest factor in the business. The environs of Chicago are producing almost as much cement as the whole of the Lehigh Valley.

Besides mixtures of clay and limestone, argillaceous limestone and pure limestone or calcite, slag and limestone, we have also as materials shale and limestone and clay and marl.

The shale and limestone introduce no complexity or important change from the type modern process except in the drying and grinding.

The marl, or what might be called bog calcite, has always been a different proposition. One of the important events which I have not previously mentioined, in the history of American Portland cement industry was the work of Millen and others in Central New York State, where such marls are plentiful. They struggled in the same way as Saylor and at
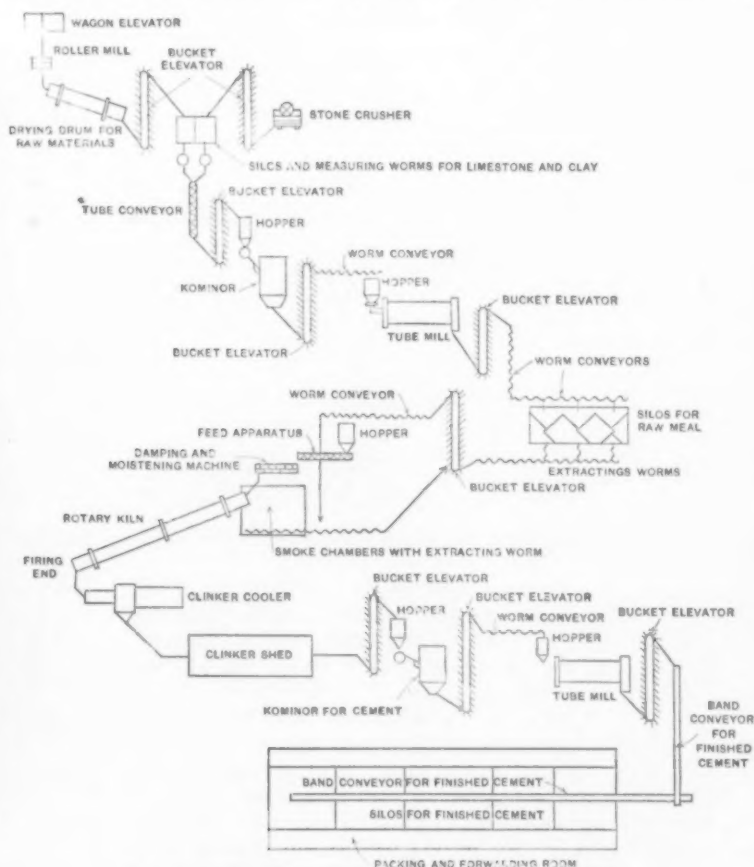
persistent effort at improvement and are about to obtain great aid from the introduction of the long kiln.

American cement engineering advanced beyond Europeon ten years ago—to-day European practice is in advance, and it is on account largely of improving in details on the American ways that most is promised from current practice in the wet way.

The explanation is this: The physical character of marl prevents the easy removal of water and also causes a slurry to carry too much water—almost 60 per cent.

The reason why wet processes failed was because no account was taken of this excess water even in the so-callled semi-wet slurry. When it was realized that this proportion of water should be cut down it was found that slurry with 40 per cent water could be pumped. But it was also found that a great deal depends upon the physical character of the raw constituents, and there are some, notably from hard materials, as limestone and shale, wherein 35 per cent to 32 per cent and even a little less may yet permit the free movement and carriage of the slurry. Great attention must be paid to

the fineness to succeed in attaining this minimum water. Thus you see the consumption of 200 lb. of coal formerly recorded against the rotary kiln in the wet method must be materially reduced. Then adopting the advantages of the long kiln for full utilization of heat and for large capacity whereby you also avoid coal for the dryer you come to a situation where a

FIG. 10.—DIAGRAM OF MODERN CEMENT MANUFACTURE.

wet process for hard materials is not only feasible but highly desirable.

In most modern European mills there is provision for drying in rotary driers between the kiln and the stack and also for saving clinker heat by under coolers taking the air for combustion first over the clinker and closing up air leaks in the front of the kiln. (Figs. 8a and 8b.)

Then we have other factors which are important, and in these I believe a well-designed wet process introduces promise of saving. The first is raw grinding. With greater capacity of mills for equal horse-power we shall have made a gain.

It was admitted, when marl or chalk or clay were used, that the wet grinding was done at an advantage. It is so with the hard stone; after crushing, the pulverizing wet will be done more economically. In an experiment with the pebble mill of F. H. Smidth & Company the following results were obtained:

Fineness.
Residue on Sieve No. 180.
13.0 per cent
8.0 per cent

Product.

Wet Grinding.	Dry Grinding.
Pebble weight	73 per cent of pebble weight
70 per cent of pebble weight	54 per cent of pebble weight

Secondly, it is safe to say that the fuel requirement in the kiln will be less by reason of the intimate contact of the particles of stone and clay—the rearrangement of the molecules in the clinkering stage will require less heat. This clinker also grinds more easily than that from less well compounded dry materials requiring high vitrification. Then there is no drier installation and no coal to be burned for it. There is no dust at the driers. The dust nuisance, in fact, is more than half

eliminated in a wet mill. This is of considerable importance in reducing losses to machinery and the actual loss of the dust itself which carries with it the cost of royalty, quarry, drier and grinder and the nuisance to the neighborhood. The dusty appearance of the air around a group of cement mills is a joy to all interested in the industry as a sign of prosperity, but it is not pretty. We ought to pay dividends in esthetic currency whenever we can spare some —for outsiders.

This process has been placed on an economical basis by the advances made in the design and construction of rotary kilns which have been brought to such a point of perfection that it is possible to have wet mixtures containing between 30 per cent and 35 per cent of moisture with the same economy and to obtain the *same capacity* as can be had from modern rotary kilns on the dry process.

The following is the record of the performance of a kiln in a modern mill in Russia working the wet process on a slurry of 38 per cent water made from raw materials:

The kiln was 150 ft. long with enlarged burning zone from 6.9 ft. in diameter to 7.9 ft. in diameter. In 26 working days it produced 14,500 barrels of 380 lb. each, or about 560 barrels per day, with a coal consumption of 24.2 per cent, or about 92 lb. per barrel. This coal contained 1.42 per cent water, and on the dry basis had a heat value of 11,500 b.t.u.

Much advance is being made in the study of the heat economics of the kiln, and the researches of Newberry, Meade, Richardson and Landis are carrying us forward by placing more accurate data before us.

In good present dry practice, in kilns 135 ft. to 150 ft. long, we are producing 750 barrels of cement daily with a kiln coal

FIG. 11.—PRICE CURVE OF CEMENT FROM 1880 TO 1909.
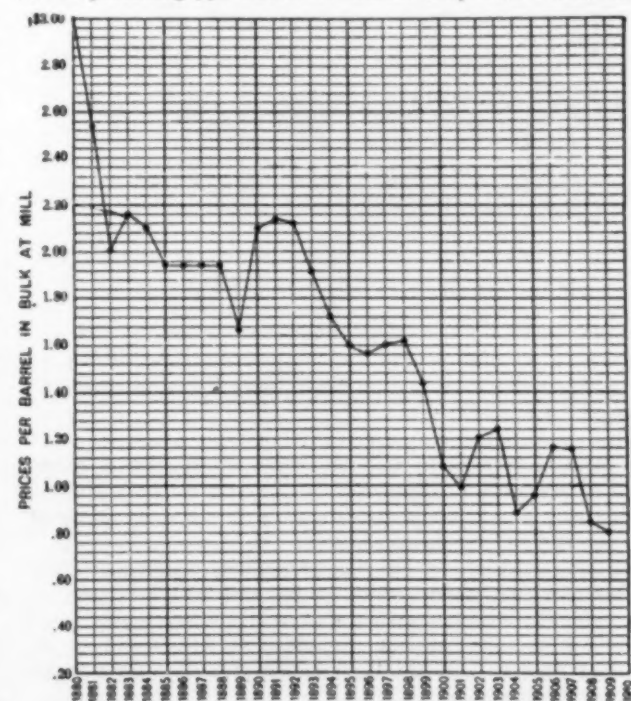
consumption of 85 lb. The product is ground to 80 per cent fineness on the No. 200 sieve. Some mills are probably doing this at a mill cost of 60 cents. I have seen figures of some which indicate that 50 cents has been reached in the best

situated and best engineered plants, and that the given good installation could do this in a given good situation for coal and raw material. But the coal and the power draft are still the items promising improvement.
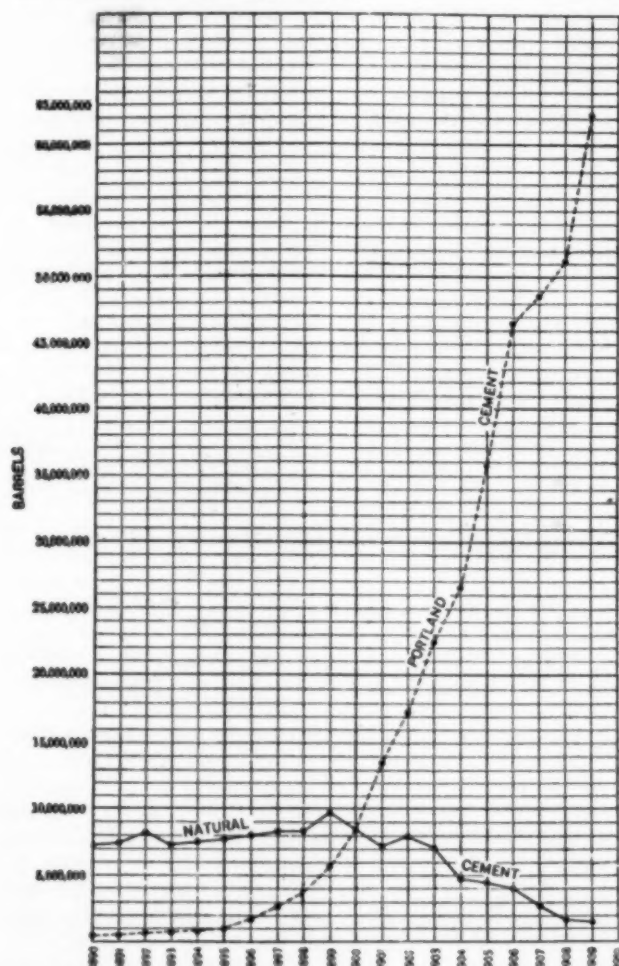

FIG. 12.—PRODUCTION CURVE OF PORTLAND AND NATURAL CEMENT.

As said before, power should be saved by wet grinding: it should be saved in grinding so-called wet-process clinker. Again, there is something promised in the way of a new discovery in pulverizing which will increase mill capacity very materially, it is claimed. This is the substitution in place of part of the usual charge of pebbles in the discharge end of the tube mill of some hard metal cylinders which, being separated from the pebbles by a screen, complete the pulverizing more perfectly and with less power.

The saving of heat from the clinker will improve in details of apparatus and considerably in efficiency. Professor Landis says that 10 lb. of coal are lost by heat of clinker, and that from 5 lb. to 7 lb. can be saved by efficient undercoolers. He has also made the important discovery that much more heat than we had supposed is generated by the formation of clinker. It is so large that in a theoretically perfect condition, with no losses, the reactions of the kiln would require only 15.7 lb. per barrel. With reasonable losses he thinks it ought to be run with four times this amount and maybe some day in some places with something like threefold that amount instead of sixfold, as we most often have it now.

Some are advocating dividing up the process again so that one kiln—perhaps the upright, which is so favorable for it in fuel economy—will be used for calcining and the more highly heated rotary for clinkering.

I have known this to succeed at one plant where the works were run economically on set kilns and rotaries. This was because the company had an excellent plant of old kilnside, and at a place where anthracite culm was cheap. The anterior burning of a mix of high and low limestone permitted them also to introduce the correction before entering the rotary.

I have said little of the power house and power transmission in speaking of these processes, but they have also had their natural stages of rapid evolution and improvement, as you all know. Electric driving, so much feared at first in the cement mill, has come to be universal.

By courtesy of Messrs. F. L. Smidth & Company, of Copenhagen and New York, I append sketch outlines (Figs. 9 and 10) which show a modern wet and a modern dry installation also which will give an excellent idea of the mechanical equipment and installation. It needs only the conception of the power house to complete the picture of modern cement manufacture in outline.

It is interesting now to notice from the statistics of the industry the influence of this evolutional development upon the prices of Portland cement.

As pointed out by Eckel, the important epochs in the history are plainly marked in the downward curve of price (Fig. 11), and the constant improvement in the economy of production is suggested in the form of the upward curve of production (Fig. 12).

It would be a very impressive reversion if a new drop in cost would be the result of studies of engineers leading to the use of water and a return to the wash-mill.

Metallurgical Notes.

Filter leaves are usually cleaned by soaking in a 10 per cent HCl solution, but this operation can be accomplished with a much weaker solution—2 or 3 per cent—if the solution is hot and delivered under a slight pressure into the center of the leaves. By forcing the hot solution through the pores of the cloth the lime is quickly dissolved.

Canvas slime tables have been built in various forms for the purpose of saving fine mineral escaping from concentrating works. One of the latest types is that devised by Mr. E. C. Porter at the Arizona Copper Company's concentrator at Morenci, Ariz. It consists of a dozen canvas tables arranged one above the other. The slime feed is allowed to run onto the tables until a coating of slime is formed, when the feed is shut off and a stream of water applied simultaneously to each deck by a traveling water pipe with suitable extensions over the several decks. When the accumulated slime is washed off the operation is repeated. The adaptation saves floor space and reduces the cost of attendance.

Grading Analyses.—In his reply to the critics of his paper on "Grading Analyses and Their Application," published in the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, Mr. H. Stadler states that an account of the laws of ore crushing and the experiments executed in that connection may be found in a work by F. Kick, entitled "Das Gesetz der proportionalen Widerstände und seine Anwendung," Leipzig, 1885. In further answer to those who object to the application of Kick's law in determining the mechanical efficiency of crushing machines, Mr. Stadler points out that, while perfectly homogeneous materials do not exist, nevertheless the definition of "equal technological state" is broad enough to include irregularities of the material so long as they are similarly distributed so that the average physical peculiarities of particles in different stages are identical. If these irregularities are, on the whole, similarly distributed, the calculations are not affected. He believes that Rand ore complies unusually well with the term "equal technological state" for the reason that it is composed of quartz pebbles of all sizes, embodied in a matrix which gives the same resistance to grinding as the pebbles.

Granular Carbon Resistance Furnace.

By J. H. Goodwin.

Several workers have described laboratory furnaces using granular carbon resistors. O. P. Watts[1] suggested embedding in the granular carbon a graphite container for a working or removable crucible. The furnace here shown makes use of that scheme and it has some other details of construction that may be of interest.

As shown in section in Figs. 1 and 2 the furnace consists of a riveted sheet-steel shell, A, 17½-in. x 12⅜-in. x 10⅝-in x No. 14 B. & S. gage, with feet and lugs of 1-in. x ⅛-in. band iron. Two 30-in. lengths of ¾-in. pipe slipped through the latter serve as convenient handles when it is desired to move the furnace. The shell is lined with magnesia-asbestos plates, B, 1 5/16 in. thick, inside of which is a thicker refractory lining, C, made by pouring in place a mortar composed of 8 parts of carborundum fire sand and 1 part of portland cement. The heating space is 7 in. x 5 in. x 3 in. and it is covered by a
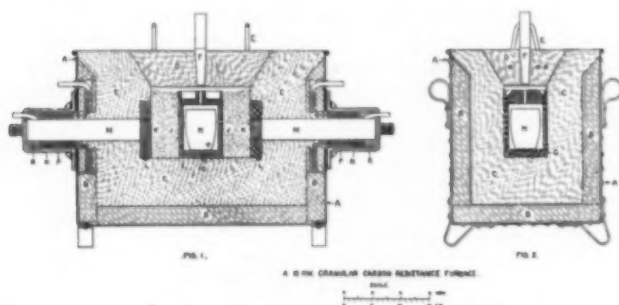
FIGS. 1 AND 2.—DESIGN OF 10-KW GRANULAR CARBON RESISTANCE FURNACE.

tapered block, D, of the same composition as the lining, containing an iron rod, E, for reinforcement and lifting and a hole, closed by a taper graphite plug, F, for watching through a cobalt glass the charge in the inner crucible. A 4¾-in. x 3-in. crucible, G, and cover, turned from Acheson graphite, occupy the center of the heating space and within this covered crucible a smaller graphite, magnesia or alumina crucible, H, containing the substance to be heated, is placed.

The electrodes are also of Acheson graphite. The plates, L, forming the ends of the heating space, are 4 in. x 3 in. x ¾ in. in size and they are firmly screwed on the 8¾-in. x 1½-in. rods, M, which fit loosely into the cylindrical part of spirals, N, of 5/16-in. copper tubing. The spirals in turn fit loosely into the brass terminals, P, attached with insulated bolts to the ends of the sheet-steel furnace shell. Good electrical connection between the brass terminals and graphite rods is obtained by sweating the latter in place with soft solder, R, which is kept cool during furnace runs by the circulation of water through the copper spirals connected by rubber tubing to the water supply and drain. Within the furnace shell the copper tubing is coiled in flat spirals in order to cool and protect the bolts and micanite insulation.

The resistor is composed of tightly tamped graphite, granular carbon or coke, K, ground to pass a 20-mesh sieve, and loosely added charcoal, J, crushed and collected between 4-mesh and 8-mesh sieves. For the first run some of the fine coke or carbon must be added to the charcoal, but after one heating this can be sifted out and the charcoal will then be of reduced resistance and the furnace can be started from 220 volts without any addition of carbon to the charcoal portion of the resistor.

With this type of furnace no electrode adjustment is possible, and, as the furnace resistance falls rapidly with increasing temperature a wide range of voltage control is essential. This can be obtained by a water rheostat, using sodium carbonate or hydrate to give sufficient conductivity, as shown in the dia-

[1]Electrochem. and Met. Ind., IV, 273.

gram of circuits in Fig. 5, but such a method is every wasteful of energy and should not be employed if the furnace is to be used frequently. It is better to operate the furnace by alternating current and control the voltage by a variable reactance, as shown in Fig. 4, or, better still, to operate the furnace from a separate alternator of which one has the field control, as shown in Fig. 3.

The refractory lining of the furnace deteriorates and requires repairing from time to time. The resistor, outer crucible and cover burn slowly while the furnace is open to change inner crucibles, but making this time as short as possible a long life for these parts can be assured and they are easily replenished or replaced. The electrodes are not so easily replaced, but they do not need to be because they show very little deterioration, being always covered by carbon, which protects them from oxidation.
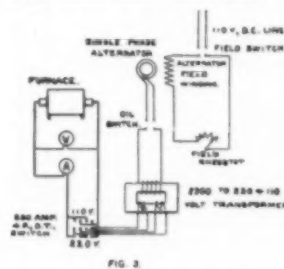
FIGS. 3, 4 AND 5.—DIAGRAMS OF CONNECTIONS FOR 10-KW FURNACE.

The furnace may be heated rapidly without injury. In one run, with a sample of platinum in the inner crucible, it was started cold with 200 amp at 200 volts. In three minutes the current had become 350 amp at 90 volts and the switch was thrown over to the 110-volt connection. Four minutes later the current was 250 amp at 70 volts and the sample of platinum was melted. Ten kw will maintain this temperature and crucibles may be heated and removed for pouring without interrupting the current or disturbing the outer crucible. The terminal cooling water carries off about 5 kw and the efficiency of the furnace is low, but for laboratory work this is compensated by the advantage of a durable, portable, compact, high-temperature unit that is not dismantled after each heat.

Fremont, Ohio.

Bakelite as an Insulator in Influence Machines.—Interesting information on the possibilities of bakelite and bakelized paper as an electric insulator is found in a recent German patent of Dr. H. Wommelsdorf for improvements in influence machines. In the past the discs, posts and other insulating portions of influence machines have always been made of glass or hard rubber. Both these materials have distinct disadvantages, the glass being breakable and the hard rubber becoming inefficient in time through electrical and chemical action. Dr. Wommelsdorf has now discovered that bakelite is suitable in a surprisingly effective manner for the manufacture of those parts of influence machines which are subject to the effect of the sparks and silent discharges and to the chemical action of the mixture of ozone and nitrogen oxide formed during the operation of the machine. Bakelite is very resistive against these influences. Moreover, by comparative tests the unexpected fact was established that influence machines, the inducing parts of which (for instance, disks) are made of this material, give an appreciably greater and almost double the quantity of electricity (coulombs) than influence machines of the same size and the same design with hard rubber disks. Bakelized paste-board is also suitable.

Heat Insulation of Furnace Walls.

By Carl Hering.

Although the fundamental principles concerning the losses of heat through the walls of furnaces are simple, yet it seems there still exists some doubt and uncertainty concerning rather elementary features, which in turn may lead to confusion, misleading statements and possibly even to positive errors.

The purpose of the present article is to endeavor to explain these general principles briefly from the standpoint of the practical engineer rather than from that of the academician, and to show how simple most of them are; also to point out some results and deductions which may be of practical value.

The analogy of a flow of heat through the walls of a furnace to that of a flow of electricity (a current) through a similarly shaped conductor are in some respects very close, and anyone familiar with the latter should not have any difficulty to understand the former. For instance, for the purposes of analogies only, suppose the inside of a cold furnace to be filled with mercury and the outside placed in a bath of mercury, all openings, of course, being closed; then by passing an electrical current from the metal in the inside to that on the outside, and measuring the voltage between the inside and outside, the electrical resistance of the walls as a whole could thereby be measured, supposing them to be sufficiently conducting. Or, knowing this resistance and the voltage, the current could be determined from them.

It will at once be seen that for any given dimensions and material of the walls, the greater the voltage the greater the current and vice versa. Hence, the voltage in that case is a direct measure of the current which leaks through. If, however, there are several furnaces, all of like dimensions but made of different materials, then the voltages for the different furnaces are no indication of the relative leakages of current, and to assume it to be so might lead one to very erroneous conclusions.

If, for instance, to take exaggerated cases in which the results require no refined calculations, the walls of three furnaces of like dimensions were made of copper, carbon and moist brick respectively, then with the same voltage for all three, the current would be enormously greater for the copper than for the carbon, and much greater for the carbon than for the moist brick. The voltage, being the same in all three, is, therefore, no indication whatsoever of the relative currents.

Now let the voltage be higher for the copper than for the carbon, the greater current will then correspond with the *greater* voltage. If, on the other hand, the voltage is greater, though not unreasonably so, for the brick than for the carbon, the greater current (namely, that in the carbon) will now correspond with the *lower* voltage; that is, just the reverse of the previous case. Hence, again, the current does not correspond with the voltage.

The same is true if a low voltage is applied to the copper and a somewhat higher one to the carbon, that is, just the reverse of the above case, yet the current for the copper would then still be the greater notwithstanding the fact that the voltage is now less. Finally, let the voltage for the brick be less than that for the carbon, the current through the brick will then still be less than for the carbon, although the relative amounts of the voltages are now the reverse of what they were above.

The conclusions from these exaggerated cases are so evident that no numerical calculations are necessary to further demonstrate them. In less exaggerated cases the difference is only one of degree, although specific cases might be selected in which the voltage might be made to appear to be a measure of the current, but if this were true as a general law, it would, of course, have to apply to all cases and it has been shown above that it does not.

The explanation, of course, is that the current is equal to the voltage divided by the resistance, hence the current depends quite as much on the resistance (hence on the material) as it does on the voltage; it is only when the resistance remains the same (namely, when the material and dimensions remain the same) that the voltage is a measure of the current.

This analogy to thermal flows is virtually a perfect one, as far as the subject now under consideration is concerned, namely, the insulation of the walls considered by themselves. The difference in temperature between the inside and outside surfaces is analogous to the difference in electrical potential, namely, the voltage; the thermal resistance (insulation) is analogous to the electrical resistance, and the flow of heat, or heat loss through the walls, is analogous to the flow of electrical current.

Hence by analogy, for any particular furnace (with fixed inside temperature), the higher the outside temperature (hence the less the drop), the less the loss, and vice versa. But in comparing furnaces made of different materials, whether of the same size or not, the outside temperature (assuming the inside temperature to be the same in all) is, as far as the walls by themselves are concerned, absolutely no indication whatsoever of the loss of heat—that is, of the insulation efficiency. The losses may be very different when the temperatures are the same, or they may be greater when the temperature is less, or less when it is greater. The loss depends not only on the temperature, but also on the total thermal resistance of the walls, and this in turn depends not only on the thermal conductivities, but also on the dimensions. But even for the same size, the outside temperature is no indication of the loss.

According to the thermal Ohm's law the flow in watts W is equal to the drop in temperature T in centigrade degrees divided by the thermal resistance R in thermal ohms.* Or $W = T/R$. Hence $T = WR$; that is, the drop of temperature in the walls is equal to the *product* of the flow and the resistance, but is not proportional to either alone unless the other is constant. If neither the flow nor the resistance is known, then the temperature is no indication of either, as for the *same* temperature in two cases W may be larger and R small, or the reverse; that is, the same temperature may be due in one case to a great flow through a small resistance and in another to a small flow through a great resistance.

Several numerical examples were given by the writer on page 125 of the March issue of this journal, hence they need not be repeated here.

The above applies to the insulation afforded by the furnace walls considered by themselves, as the heat insulator of the furnace, and as this is in almost all cases one of the two chief purposes of the walls it applies to the general case, and the principles enunciated above may be said to be the chief fundamental ones concerning the relations between the flow, the thermal resistance and the drop of temperature. It is, of course, assumed herein that all the heat reaching the outside surface is freely dissipated as fast as it gets there and without any obstruction to such dissipation; the effect of such possible obstruction will be considered later.

Besides these fundamental considerations there are some minor or less important ones, just as is the case in most other problems, and they modify the general results somewhat. They are of more interest to the academician than to the practicing engineer. To include them in calculations may be said to be a refinement, or a second approximation, as it is often called; but in most furnace calculations which the engineer has to make, and which are necessarily somewhat crude in the present state of our knowledge or lack of knowledge of the physical properties of the materials involved, these minor features may generally be neglected or allowed for as correction factors instead of attaching the same importance to them as to the fundamental ones, whereby the problems would often be hopelessly complicated. Among these may be mentioned the

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*For the definition of a thermal ohm see the article on this subject in the January issue of this Journal, p. 13. (Article on thermal resistance and conductance; the therman ohm and thermal mho.)

temperature coefficient of the thermal resistance, and the further variation of this coefficient with the temperature. This will undoubtedly effect the results somewhat, from the academician's standpoint, and will afford him the means of making the formulas and analyses very complicated, while in their unburdened or fundamental form they are very simple and easily understood. Moreover, as our knowledge of the numerical values of the resistivities or conductivities themselves is to-day still in a somewhat crude state it seems unreasonable to lay much stress at present on any refinements of these values. If the engineer has given to him reasonably reliable values for the usual materials when hot and when cold, it will suffice for most of his purposes and it will generally not be necessary for him to complicate the analytical work with the introduction of temperature coefficients.

Another one of these less important features, which, in the opinion of the writer, are best considered as secondary ones, to be introduced as corrections rather than being given the importance of a fundamental feature—is the rate of dissipation of heat from the outside of the furnace to the air or water jacket when this dissipation is restricted as distinguished from being virtually free and unlimited, as it would be with a good water jacket, and as it was assumed to be in discussing the fundamental relations above. If the outside surface is large enough or sufficiently exposed to draughts or water circulation to dissipate all the escaping heat freely so as not to bank it up, then the resistance which the flow of heat meets at this surface may be neglected; or it may be roughly allowed for on the basis that for a given kind of surface and a fixed room or cooling water temperature the greater the heat dissipated per square foot the higher will be the temperature which that surface will assume. With restricted dissipation that temperature will, of course, be higher, but in either case the rise will not be nearly as fast as the increase of the heat dissipated per square foot; according to Stephan's law the radiation varies with the fourth power of the temperature (absolute scale), hence to dissipate a considerably greater amount of heat by radiation would involve only a relatively small rise in temperature of the surface.

While, therefore, it is undoubtedly a fact that theoretically the temperature of a given surface will increase when the amount of energy dissipated from it increases, yet the obstruction to the heat flow which causes this appears to be too small relatively to the resistance of the walls to be given much importance; the wall insulation is the important one, the other is of only secondary importance. If, for instance, the fall of temperature from the inside to the outside of the wall is a drop from 1800° to 118° (see example below), namely, 1682°, and that from the outside (118°) to the air at 20° is 98°, the walls will, as an insulator, be more than 18 times as important as the superficial resistance to dissipation; the latter is in this case only 5.5 per cent of the total effective resistance, and it is, therefore, certainly of only secondary importance.

In this connection, however, attention might be called to the advantages of treating or covering the outside surface of the walls to obstruct and hinder as much as possible the dissipation of heat from it, as could be done for low temperatures by a thin layer of cork, for instance. This would increase the insulation efficiency, or for the same efficiency, would reduce the thickness of the wall required for insulation; the hotter the outside of the wall of a given furnace, the less the heat loss through that wall. But in that case this outside coating must, of course, be able to withstand that higher temperature when exposed as it is to the free oxidizing influence of the hot air.

If it were possible to find some coating for the outside of a furnace which would resist the dissipation of heat to so great an extent as to form a sufficient insulation of the furnace, then the insulation afforded by the walls might be neglected and the walls made as thin as other considerations would permit. In that case the lower the temperature just outside of this wall, the less the heat loss. But this is, apparently, more

of theoretical than of practical interest, as at present the chief insulation is afforded by the body of the furnace wall.

Theoretically the temperature which the outside surface of a furnace will naturally assume when the dissipation from that surface is appreciably restricted, that is, when it is not free and unlimited, is that at which the heat flow to which the dissipation from that surface is restricted, is exactly equal to the flow reaching it through the walls; this is the stable state and the temperature will rise or fall until that state is reached. For a given furnace with a given inside temperature and with restricted dissipation from the outside, the higher the temperature of the outside surface the less will be the flow through the walls, but the greater will be the dissipation of heat from the surface; hence, as the one diminishes while the other increases, the stable state is reached more quickly and the changes of temperature corresponding to changes in flow are necessarily less than they would be for either alone or if both changes were in the same direction.

As was shown above, the resistance due to this restricted superficial dissipation is of relatively small importance compared with that offered by the walls, and the temperature rise which it produces is, therefore, probably of more interest to the academician than to the engineer. Moreover, that so-called stable temperature is so greatly dependent upon the surrounding temperature, hence on the weather and the seasons, as well as on draughts, the temperature of nearby objects, the presence or absence of nearby walls or other objects, etc., that no great importance can be attached to it.

As a recent statement, however, attaches sufficient importance to this outside temperature to recommend it as a "very good" means for measuring the losses of heat through different furnaces and for comparing the losses and the efficiency of the material of the walls, the writer has made the following approximate analysis of the relations, not because he considers it of much importance, but because the question was raised.

To treat it analytically involves very troublesome equations of the fourth degree. Moreover, the laws concerning the convection of heat from surfaces are complicated and involved if at all definite. But to solve this problem in this way one would express the heat flow through the walls algebraically in terms of the unknown outside temperature, then express that dissipated from the outside by radiation and convection in terms of this outside temperature also. The flow is, of course, the same in both and so is the outside temperature. Hence this gives two equations with two unknowns, and they can, therefore, be solved for both. The result seems to be of too little interest to warant the labor.

The engineer is usually satisfied when he knows that such a result is not of much importance, and this can be shown by means of a simple graphical method applied to the following actual numerical cases.

The following dimensions and data have been chosen to simplify the calculations rather than to serve as an example of a good design; also chiefly in order to adapt them to the small range of the available data, given in the very convenient curves of Mr. Snyder, for the sum of the radiation and convection losses from the surface of bricks to the air at various temperatures, as given in the *Transactions* of the American Electrochemical Society, Vol. 18, 1910, page 239. The writer here assumes their correctness, as he has not confirmed them.

Assume a furnace of silica brick; inside dimensions 6 in. x 6 in. x 6 in.; thickness of walls, 9 in.; hence outside dimensions 24 in. x 24 in. x 24 in.; inside temperature, 1800° C.; room temperature, 20° C.; thermal resistivity of silica brick, about 48 thermal ohms. Hence inside surface is 216 sq. in.; outside 3460 sq. in. = 24 sq. ft.; the mean (geometric) cross-section perpendicular to the flow is the square root of 216 × 3460 = 866 sq. in.; hence the total thermal resistance is 48 × 9 ÷ 866 = 0.50 thermal ohm. The graphical solution consists in calculating by means of the well-known formula

watts = drop in temperature ÷ resistance in thermal ohms.

the flow through the walls for each of several assumed temperatures of the outside of the walls; then plotting them as shown in the adjoining figure and drawing a curve through them, this curve is marked "walls," representing the part which the walls take in determining the total loss. It will be seen that this line is nearly horizontal, showing that the loss is nearly the same for all of these outside temperatures, hence nearly independent of them. Under such circumstances it would be very poor practice to measure the flow by means of these small differences of temperature.

Then calculate for each of those same assumed temperatures of the outside of the walls, the flow of heat in kilowatts which will be dissipated from the 24 sq. ft. of outside surface by multiplying that surface by the constants for each of those temperatures, obtained from Mr. Snyder's curves, on the assumption that they are virtually the same for silica brick as for firebrick. The results when plotted are shown in the curve
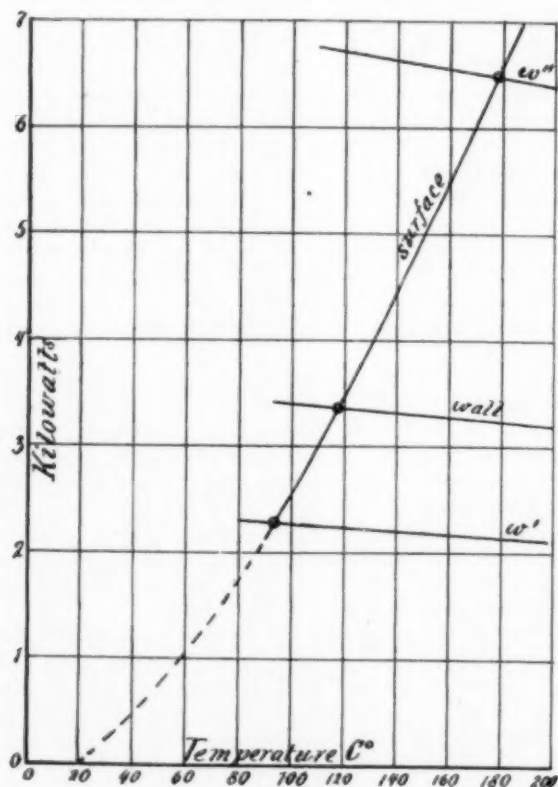
HEAT CONDUCTION THROUGH FURNACE WALLS.

marked "surface." It will be noticed that this curve is very steep, which means that this temperature varies only slightly for a very large variation of the flow. That is, the flows are not greatly dependent upon those temperatures. Hence for this reason also it would not be good practice to measure the former by means of the latter.

It is evident that the stable state will be reached when the temperatures for each of the two curves are equal, hence the desired value is at the point of intersection of the two curves at which, of course, the flows are also equal. Hence in this case the outside stable temperature will be about 118° C. and the loss of heat about 3.35 kw.

As remarked above, this temperature is a very unreliable figure as it depends on the weather, draughts, etc., and, in the opinion of the writer, would for that reason alone be unfit to be taken as even an approximate measure of the relative losses or of the relative insulating values of different wall materials. But to show that it would be a poor figure to use as a measure for comparing different wall materials, even under very carefully maintained laboratory conditions, hence even for the

academician, two more curves have been calculated, one marked w' for a material having a resistance 50 per cent greater, namely, 0.75 thermal ohm, hence probably greater than any suitable material would have, and the other, w'', for one having a resistance 50 per cent less, namely, 0.25 ohm, hence half as great as the original one and extremely low. These three examples, therefore, cover very wide ranges.

It will be seen that the stable temperature for w' will be about 94°, hence only 24° less, although the difference between the two materials as insulators is quite great, namely, 50 per cent, and although the relative losses are reduced from 3.35 kw to 2.3 kw, hence also quite a great difference.

The former loss is very nearly 50 per cent greater than the latter, which shows that the total loss is determined almost entirely by the resistivity of the wall material and that the slight change in outside temperature is of practically no importance in determining the flow or loss and may, therefore, safely be neglected.

The results for the curve w'' are similar. The stable temperature then will be 178°, or only 60° higher, although the material is only half as good an insulator as the original. The flow, 6.5 kw, is very nearly double the original, showing again that the resistance of the wall material is decidedly the governing factor for determining the flow and that the outside temperature may safely be neglected, except that one must, of course, expect a somewhat higher outside temperature when the flow is considerably greater.

This analysis shows that the curve marked "surface" is very steep as compared with the others, which means that as far as the surface dissipation is concerned only a few degrees rise (horizontal distances) will cause the surface to dissipate very much more heat (vertical distances). Hence to determine the flow by means of this temperature is like determining the movement of the long end of a lever by a crude measurement made at the short end; a very small error in the measurement will give rise to a very large one in the result that one is striving to get.

To measure such temperatures accurately on the outside wall of a furnace and to expect to get concordant results would, in the writer's opinion, be a hopeless task; they would probably differ by 50 per cent on different parts of the same furnace at the same moment. And even if a mean of such very unequal readings had any value as such, it would be of little use because we know too little about the constants for the dissipation of heat from surfaces, and, therefore, could not intelligently interpret the temperature in terms of resistances or losses even if the values of the temperature were accurate.

There is still another feature involved in this question of heat insulation which may also not be clearly understood and which is of greater importance. It bears on what might be called "over insulation." In this feature the electrical analogy misleads one instead of helping one.

Regret has often been expressed that nature has given us no practically perfect heat insulator (other than a vacuum), such as rubber is as an electrical insulator. This is not so serious, however, because in the very cases in which it would be most desirable, namely, for high-temperature furnaces, such an insulator could not be used even if it existed.

Suppose, for instance, a furnace was surrounded by a vacuum, which is the most perfect heat insulator known. A vacuum insulates only against convection of heat, but not against radiation, as we know, because we get our heat from the sun through a vacuum; but in the present argument the radiated heat is considered zero by the assumption of a perfect insulator.

In such a furnace the heat will at first flow toward the outside; as it meets with the vacuum it can go no further, hence will accumulate and it will continue to do so until the outside is at the same temperature as the inside. This, therefore, means that the walls of the furnace will throughout their whole thickness reach exactly the same temperature as the inside of the

furnace, and for high-temperature furnaces this means that the whole furnace would soften and melt. Hence a perfect insulator could not be used even if it existed. Some flow of heat must, therefore, be allowed for in order to keep the walls from melting; the problem is to find the least possible amount which will still do this. This much-desired perfect heat insulator around the cylinder of a gas engine, for instance, would be fatal to the cylinder.

Again it might be argued, why not surround the outside of a furnace with cotton, mineral wool, very fine magnesia or some similar material which has a very high thermal resistance due to its holding air in its pores so that the air cannot move, still air being one of the best insulators.

The same reasoning as above will show that in such a case the outside of the bricks, where the outflow of heat nearly ceases, would soon become very highly heated and unless they and the outside porous insulator can stand this high temperature the furnace would fail.

It has no doubt often happened that parts of furnaces have thus been melted away due to over insulation, when such melting might have been prevented by allowing a greater heat flow to pass through those parts by insulating them less. Too great an economy of heat loss may result in other more serious losses; a good thing may be overdone; the loss of a furnace wall may be much more expensive than the loss of some heat.

One of the cheapest and best insulators seems to be a joint. Hence, for good insulation the bricks should, if practicable, be laid dry and so that their flat sides are perpendicular to the flow of heat, as this gives the maximum number of joints in the path of the flow. But, as described above, this might result in the melting of the inside layer of bricks, hence it should be done cautiously.

Of course, whenever the maximum temperature of the furnace is never high enough to soften the brick, then over-insulation need not be feared.

Philadelphia, Pa.

Notes on Cripple Creek Mill Practice.

Editorial Correspondence.

The interest which, for the past two years, has centered in the cyanidation of Cripple Creek raw ore will not abate much this year. In fact it is more likely to increase for the reason that we do not yet know the chemical details of one of the processes used, and further, that a wholly new principle is to be applied this year in a new mill now building. The successes of 1909 and 1910 will be followed, we hope, by still another in 1911, and the field for local treatment of Cripple Creek ores be thereby greatly enlarged. It seems certain even now that the list of metallurgical failures at Cripple Creek will not be added to if intelligence is displayed by those who direct future ventures.

At the present writing the secret of success is told in a few words—ordinary cyanidation assisted by preliminary concentration and the application of cheap chemicals with the cyanide. The object of the concentration is to remove a small quantity of refractory mineral, the retention of which would only increase the time of extraction of the whole mass, or possibly defeat the whole process. The comparatively small quantity of the ore thus removed can be sold to smelters or given such special treatment as it requires. But the prospect now is that even this step will be rendered unnecessary by the Clancy process which will be in operation in a few months.

Stratton's Independence Mill.

The method of treatment used in this mill was worked out by Mr. Philip Argall after many years' experience with the cyanide process and Cripple Creek ores. Based on experiments made at a much earlier date, the plant finally was put in operation in April, 1909, after some unavoidable delays and in spite of the unfavorable criticism of doubting Thomases.

The problem was to treat at a profit a large dump of low-grade ore, amounting to almost 1,000,000 tons, which had accumulated for many years. The average value of the dump was determined by extensive sampling to be $3.80 per ton. This figure is much lower than the cost of treatment at some of the earlier mills and is even less than the lowest treatment rate now offered by custom mills on low grade Cripple Creek ores, viz., $4 per ton. That the cost of treating this dump in the Independence mill is about $1.50 per ton is evidence of the general improvement in milling methods and of the ability of the technical staff in charge of the work. The mill was the first successful cyanide plant treating sulpho-telluride ores in the Cripple Creek district, although several successes had been scored previously in cyaniding the oxidized ores. It has been steadily enlarged since beginning operations from an original capacity of 4500 tons per month to practically more than 9000 tons per month at the present time.

Crushing and Grinding.—The dump ore is mined by electric shovel, loaded into 4-ton cars and hauled up an incline to the coarse crushing plant. Two cars are in use, one being loaded while the other is dumping. In this way a car is loaded and dumped about every three minutes, which permits crushing a day's run of 300 tons for the mill in about four hours. The cars are dumped directly over a 7½ D Gates gyratory crusher which reduces the ore to 4-in. size. The crushed ore is discharged over a grizzly with 2-in. openings, the oversize falling onto a picking belt where pieces of steel and wood are removed. The belt discharges into a 5 K Gates gyratory which crushes the ore to 1½-in. size. The product of the second gyratory is combined with the undersize of the grizzily and elevated by a belt conveyor to the storage bin in the concentrator building.

The design of the storage bin and feeder insures a positive steady feed of ore. The bin is circular with conical bottom, the cone terminating in an opening 6 ft. in diameter, through which the ore feeds into an open cone about 12 ft. in diameter at the top and placed with its upper openings in the same horizontal plane with the 6-ft. opening of the main bin. The lower cone terminates in an opening about 12 in. in diameter, through which the ore is discharged by a revolving table feeder. By this construction the ore flows freely and the bin may be completely emptied without extra attention.

The method of adding lime for protective alkalinity differs from the usual practice of adding it in a solution form. As the ore leaves the storage bin it is moistened with a small quantity of mill solution, which settles dust and slakes the solid lime, which is added continuously at the rate of about 1000 lb. for the day's run of 300 tons of ore. This gives a protective alkalinity in the solution of .002 per cent. The mixed ore and lime are then elevated to bins above the rolls, and further reduced in two successive sets of rolls to ⅜-in. size. This material, which constitutes the Chilean mill feed, is then elevated and distributed to three bins, one for each mill. The Chileans are of the fast running type, 6 ft. in diameter, making 33 r.p.m. They grind in mill solution which is kept at a strength of about ½ lb. KCN per ton and discharge through 12-mesh screens. The capacity is about 100 tons of ore each per 24 hours, 60 per cent of the pulp passing 150-mesh screen.

Classification.—Sand and slime are classified prior to concentration in two spiral classifiers, each of 300 tons daily capacity. The sand is delivered 5 ft. above the feeding point, carrying from 4 per cent to 7 per cent slime, depending on the varying nature of the ore. The slime emerges 6 in. below the feeding point, carrying about 3 per cent of sand coarser than 150-mesh.

Sand Concentration.—Mill solution is added to the sand as it leaves the classifier, and the pulp is distributed to 20 Card tables. Two grades of concentrate are obtained, the first carrying about 5 oz. gold per ton, which is shipped to the smelter; the second with about 0.75 oz. gold, which is sold to

chlor nation works. The Card table is preferred for this work as it gives a cleaner division between the two classes of concentrate and a consequent financial advantage in their disposition. The sand tailing is laundered to a sump and delivered by centrifugal pump to the cyanide plant for further treatment.

The coarser and heavier sand is separated by spitzlutten and reground in a tube mill. The reground pulp is classified by cones into sand and slime, the former being treated on two Card tables and the latter on four Deister slimers. All of these tables produce first and second grade concentrates.

Slime Concentration.—The slime from the classifiers is thickened in 16 8-ft cones. The underflow is distributed to 10 Deister slime tables and four vanners. Like the Card tables, the Deisters make two grades of concentrate, the first carrying about 7 oz. gold per ton and the second from 0.50 oz. to 0.70 oz. The total concentrate removed by sand and slime treatment amounts to about 3 per cent by weight of the ore treated and contains 40 per cent of its value. The tailing from the Deisters and vanners is laundered to a sump which also receives the overflow from the thickening cones and the tailing from the tables treating reground sand. A centrifugal pump returns the slime to the cyanide plant for further treatment.

Cyanide Treatment.—The regular cyanide treatment is supplemented by the use of bromo-cyanogen. The sand and slime pumped from the concentrator are delivered to the head of the cyanide mill where they are reclassified. The sand is discharged to a reciprocating conveyer which distributes to six sand filter bins, each of 250 tons capacity. The sand enters the bins with an assay value of 0.06 oz. to 0.08 oz. gold per ton and is discharged, after treatment, with 0.03 oz. to 0.04 oz. The treatment is as follows: After a bin is filled and drained it is leached with solution strengthened by the addition of 25 lb. KCN to each bin. When this solution has filtered the sand is given successive washes with barren solution and water and sluiced out.

The slime from the classifiers flows to four large settling tanks, the overflow from which is usually returned to mill solution storage. It is the intention to keep the mill solution at a strength of ½ lb. KCN and at a value not exceeding $0.50 per ton. When this is exceeded the tanks are not allowed to overflow, but are decanted to the precipitating department. The thick settled slime is drawn from the bottom of any one or all of the tanks and pumped to the agitator for 10 hours agitation, with air at 30 lb. pressure. A charge consists of from 75 to 100 tons of dry slime and from one and one-half to two times that amount of solution. Thirty lb. KCN are added to each charge. The agitation tanks are modified from the standard construction in air agitators by shortening the central tube one-half, thereby securing the full benefit of the air in agitating the pulp in the upper half of the tank. After 10 hours' agitation the charge is pumped to a second agitator for special chemical treatment.

Filtration.—The vacuum filter is of peculiar construction, generally according to the Cassell type, and consists of 110 leaves 7.5 ft x 6 ft. The capacity is sufficient to handle the contents of an agitation tank in seven or eight charges in 24 hours, three hours being the time required for a complete cycle of loading, washing and discharging. Vacuum is maintained at 10-12 in., which is practically the best obtainable in slime filtration at the altitude of 10,000 ft., where the barometer normally stands at about 20 in.

Precipitation.—The filtered gold solution is clarified in two Johnson presses and flows to the zinc boxes for precipitation. The daily tonnage of solution precipitated is about 350 tons, or little more than the tonnage of ore treated. Occasionally, when the mill solution rises too high in value, several hundred tons may be precipitated in addition to the regular quantity.

The gold precipitate receives the usual acid treatment and is discharged to a pressure tank connected with a small filter press. The press cake is dried, roasted and ground in a small

tube mill using pieces of shafting for the grinding medium. The object of the last step is to put the precipitate into as uniform condition as possible so that an accurate sample can be taken. Prior to the introduction of this practice a great deal of time was consumed in making settlement with the smelter on account of the variation of the sample taken for assay.

The Independence mill was erected at a cost of over a quarter of a million dollars. The preliminary experiments indicated that a fair profit could be made by the treatment of 10,000 tons per month, and it is interesting to know that the actual working costs have checked the estimates remarkably close. No official figures have yet been given by the company, so that details of costs and profits are not actually known to the public, but it is stated that operations are being conducted at a satisfactory profit.

The mill is equipped with duplicate pieces of machinery at those points where a break would interfere seriously with continuous operation. Cement floors, launders and sumps effectually prevent the loss of valuable cyanide solution and contribute to the cleanliness of the plant. Crushing and concentrating in cyanide solution, which was one of the features concerning which skeptics expressed their doubts, has not given rise to any trouble, either by serious loss of solution or by ill effects on the workmen. Altogether the plant has been a success on which the company and staff are to be congratulated.

Following is a condensed statement of the flow of ore through the mill:

Ore from dump in 4-ton cars, to 1.

1—7½ D Gates gyratory, discharging to 2.

2—Grizzly; oversize to picking belt, thence to 3; undersize to 4.

3—5K GGates gyratory, discharging to 4.

4—Incline belt conveyer to 5.

5—Mill storage tank; lime and a small quantity of mill solution are added to the discharge and the mixture elevated to bins, thence to 6.

6—Two sets of rolls; product elevated to bins, thence to 7.

7—Three 6-ft. Chilean mills, 12-mesh screen; discharge to 8.

8—Screw classifiers; sand to 9, slime to 14.

9—Distributor to 20 Card tables; high grade concentrate to smelter and low grade to chlorination mill; tailing to 10.

10—Sand tailing sump; centrifugal pump to cyanide department, 17. Coarsest sand reground in tube mill; product to 11.

11—Two classifying cones; underflow to 12, overflow to 13.

12—Two Card tables; concentrate shipped, tailing to 16.

13—Four Desiter slime tables; concentrate shipped, tailing to 16.

14—Sixteen thickening cones; underflow to 15, overflow to 16.

15—Ten Deister tables and four vanners; concentrate shipped and tailing to 16.

16—Slime tailing sump; centrifugal pump to cyanide department, 17.

17—Cyanide mill; screw classifiers; sand to 18, slime to 19.

18—Sand leaching tanks; filtrate to 23, sand discharged.

19—Four settling tanks; overflow to mill solution or to 23; thickened pulp to 20.

20—Agitating tank for 10 hours; thence to second agitator for special chemical treatment for six hours, thence to 21.

21—Storage tank for filters, to 22.

22—Vacuum filter; gold solution to 23, slime to discharge.

23—Two Johnson clarifying presses, to 24.

24—Seven zinc boxes; barren solution to mill storage; precipitate to acid tank and filter press. Press cake dried, roasted, pulverized, sampled and shipped to smelter.

The Colburn Mill.

The latest development in the local treatment of ore at Cripple Creek is the decision of Mr. E. A. Colburn, principal owner of the Ajax mine, to erect a mill embodying the much discussed Clancy cyanide process. This will be the first commercial application of the Clancy principles and the outcome

will be awaited with great interest. Metallurgists generally are favorably impressed with the principles of the process and earnestly hope that the first installation will successfully meet the prime requisite of making money.

The Colburn mill, as it is to be known, is being erected near the Ajax shaft, above the town of Victor. Both mine and dump ore will be treated. The plant will comprise two principal buildings, one for crushing and sampling and the other for cyanide treatment. The excavations have been made, concrete foundations put in and it is expected that the plant will be in operation this summer, probably in June.

An aerial cableway will be installed for transporting ore from the dump to the sampler, while mine ore will be delivered from the shaft by electric tramway. The sampler will have a capacity of 100 tons in eight hours and will have to be run two shifts to supply the cyanide plant, the capacity of which will be 200 tons in 24 hours.

The sampler will be arranged for the separate treatment of leasers' and company ore. Coarse crushing will be done in a Symons gyratory, the product from which will be elevated and diverted to steel bins. One of the latter will be a scale hopper bin for leasers' ore and the other an ordinary bin for company use. From these bins the ore will be elevated to the roll and screen system. The sample will be taken by two Snyder samplers when the ore is reduced to ¼-mesh. The final roll product will be reduced to 12-mesh and elevated by belt conveyer to the cyanide plant. An exhaust dust collecting system will gather the dust from various parts of the sampler and conduct it to a settling chamber with hopper bottom, from which it can be drawn onto the conveyer belt and sent with the ore to the mill.

At the head of the cyanide mill will be three grinding and classifying units, each consisting of a storage bin for crushed ore, a classifier and a tube mill. The bins will be circular in form, built of steel, with bottoms of rock and cement sloping at an angle of 45°. The ore will flow from the bins into the classifiers, which will be of the spiral vane form. The slime will overflow to the agitators and the sand will be ground in tube mills. The tubes will be of a shorter type than customary, 5 ft. x 16 ft., and will have El Oro lining and screw feed. They will grind in closed circuit, their discharge being returned to the classifiers.

The air agitators will be of special construction, suited to the application of electrolysis as well as of agitation. The form will be circular, with cone bottom, and the ratio of height to diameter of the circular portion will be 1:1. The central air tube will be about half the height of the tank, so that the pulp in the upper half of the tank will be thoroughly agitated by the air rising from the central tube.

The agitators will be fitted with electrodes for the application of the electric current during agitation, both for extraction of the gold from the ore and for regeneration of the cyanide solution. The cathode will be in the form of iron sheets suspended in the pulp around the inner periphery of the tank, and the anode of fused ferric oxide suspended near the center. There will be five of these tanks, which will be used for storage as well as for agitation.

The Moore vacuum filtration system will be used. On account of the location of the mill with respect to the town of Victor and adjacent mining property it will not be possible to discharge the slime tailing by sluicing. An automatic system of stacking the tailing on the dump is now being worked out whereby the tailing will be removed from the Moore tank by a screw conveyer and delivered into a hopper. From the hopper it will be carried by bucket tramway to the dump. It is planned to make the loading and dumping automatic and to have the bucket dump at a series of different points on successive trips.

The Merrill system of zinc dust precipitation will be installed and the gold refined at the mill.

The plans contemplate a mill as nearly automatic in operation

as possible, with a minimum labor requirement. It is expected that two men for each of two shifts in the sampler and two for each of three shifts in the mill, in addition to the superintendent and chemist, will be sufficient. The mill design and construction is under the direction of S. A. Worcester and the metallurgical details are being worked out by A. W. Warwick.

Essential Points in the Management of a Chemical Industry.

By John Woods Beckman.

In every chemical industry the "chemical control" and the "chemical balance sheet" are two fundamental points which demand the closest attention. They are the backbone. Without them no chemical industry can be carried on successfully nor can the fullest return from the investment in the plant be expected.[1]

"Chemical control" is understood in a general way to mean not only the absolute knowledge, on the part of the factory managers, of the chemical constituents in the raw materials that enter the factory at one end and the finished product leaving at the other end, but the "chemical control" involves the chemical knowledge of each individual step in the whole process.

Naturally the chemical control is distinctly a chemical question, and is in the special charge of the chemical engineer at the plant, and to do the chemical work it necessitates the equipping of a first-class laboratory, with an outfit well adapted to accurate, quick routine work, as well as offering the possibility of carrying out the most complicated analysis and doing some research work. The laboratory and its staff of men and boys are the tools for the efficient carrying out of the chemical control, and the control can only be carried out in conjunction with the laboratory. On this account the chemical staff can not be too well selected, as it is the heart and brain combined of the factory.

A great number of analyses of more or less importance have to be turned out daily by the laboratory. The most important ones are the determinations made of the incoming raw materials, which cannot be given too much care. The importance of these determinations is twofold, being based on financial reasons as well as on factory-operation reasons.

The raw materials purchased, or credited to the factory, have to come up to contracted for or specified contents, and the only guide as to the accuracy of the bills presented is a most careful determination of percental composition of the raw materials.

With this knowledge at hand of the incoming raw materials it is possible for the chemical engineer to arrange the process accordingly, but of almost equal importance is the knowledge of the actual amounts of every small unavoidable admixture occurring in the raw materials. These are often the makers or the spoilers of a process, and on this account it is of vital importance to the industry that the raw material analysis be carried out to the utmost completion, even having the "traces" determined.

Catalytic action is more and more being appreciated in the carrying out of a chemical process, and Ostwald says that "there is probably no kind of chemical reaction which can not be influenced catalytically, and there is no substance, element or compound, which can not act as a catalyzer," and his words are being verified each day. Many are the chemical industries that have stumbled and fallen for unexplainable reasons which could have been remedied if a complete knowledge had been available of all the ingredients of the raw materials.

As is well known there are catalytic agents which assist the chemical reaction, while there are such which produce opposite phenomena, called negative catalysis, retarding and upsetting

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[1] In this article no mention is made of the management of financial matters nor of labor.

the normal course of the chemical reaction. With a fair knowledge of the catalytic phenomena, and with a complete knowledge of the constituents of the raw materials, it is possible for the chemist very often to remove stumbling blocks in the factory, and again improve conditions by some small addition of a foreign substance to act as a catalytic agent. The only safe way that makes it possible to improve the process or prevent destruction is the complete knowledge of the ingredients in the raw materials.

With these complete records at hand it is possible in most cases, if the mechanical manipulation of the process is the same day out and day in, to speedily overcome any unevenness in the working of the plant due to any increased or decreased amount of admixtures to the raw materials.

The utmost care in regard to the raw materials will undoubtedly repay in more than one way, but perhaps equally important from another point of view is the careful chemical control of the various steps in the chemical process. Day out and day in without fail the routine analyses—the safety valve of the process—have to be made and tabulated.

The tabulation of the analyses from day to day is exceedingly important. It shows at a glance how the whole process is working and whether the fullest yields at the different steps are obtained. The more graphical the tables are the more valuable they are. The day to day variations are often scarcely noticeable, but the week to week and month to month, and often year to year, variations count, and if they are carefully studied often losses can be avoided and improvements noticed that otherwise would totally have slipped attention.

This daily factory record is of fully equal importance to the operation of the factory as the log is to the captain of a vessel to bring it safely into port. The records have to be planned and kept in such a manner that they give sufficient information, making it possible for a person familiar with the work to take them up thousands of miles away and be able to draw conclusions and direct the operation of the plant at that distance. Any clerk sufficiently instructed can keep the records, but the planning and the drawing of valuable conclusions from them are only possible for the chemist with an observing mind and a wide knowledge.

Where chemical control to the full extent of the meaning of the word is instituted in the factory there is no hesitancy in mode of operation; complications that may arise can be traced to one or more factors, which will be very apparent after a comparative study of the records, and after doing this it will be in most cases an easy matter to bring back the process into the successful grooves.

The factories where chemical control is not instituted and no records exist excepting such as may by chance have been scribbled on the wall by a foreman or a laborer, or scattered notes in the office with no meaning at all, are in a state of upheaval when a snag is struck. General consternation reigns. The chemist, the foreman, the laborer, the manager all have their own opinion why this and that and another thing happened, and what is the most expeditious way of overcoming the trouble. Time is lost and the whole process is liable to be upset with subsequent money loss to the stockholders.

The "chemical balance sheet" is, again, a record which is of equal importance with the "chemical control." The former deals exclusively with weights, while the latter deals exclusively with percentages. The "chemical balance sheet" is generally understood to represent the bookkeeping of the process. The balance sheet has to be kept up for every day with the same care as the bank keeps up its balance sheet. Every cent has to be accounted for which has been handled during the day in the bank. Similarly should the factory management be able to account at the end of the day for every pound of the raw material stock, how far it has gone on its way through the factory, how great the losses are in the different steps of the process, and finally should the losses, together with the amount present in the finished product, total up to the raw material stock consumed during the day.

In some processes these items are hard to obtain daily, especially so in continuous processes. In such cases the balancing should be done at as frequent intervals as possible to avoid any cumulation of errors. This balancing of the process cannot be too rigid, missing nothing, and should in accuracy compare with the financial balancing of the assets and liabilities.

In close connection with above records come the determinations of the efficiency[2] of the various steps and apparatuses used in the process. The factory with the highest efficiency record is the most economical factory, and is the money-making factory, often much to the astonishment of its competitors. It is able to pay dividends, while its competitors are barely able to keep the wheels turning.

The daily records of the efficiency will quickly show their value and repay the trouble in keeping them. Suppose that an apparatus designed to dry with steam only utilizes 50 per cent of the drying capacity of the steam at that temperature, it is apparent that an enormous waste of fuel and calories takes place at that point. This would not be noticed to its full extent excepting by the careful keeping of a daily efficiency record.

In any chemical or electrochemical industry it is possible to determine efficiencies. They may be relative or absolute. The absolute efficiency is in some cases impossible to obtain, and while the absolute is very much desirable, the next best is a relative efficiency. The zero point from which to start the efficiency determination has to be arbitrarily chosen, and it may occasionally happen that the efficiency shows a figure higher than 100 per cent, which only indicates that the zero point has been chosen too high.

The points briefly dealt with above are very far reaching. They are not new, though altogether too little attention is given them for the good of the chemical industries and the pockets of the stockholders. The same principles have been applied to questions of money in the financial world and in other industries. In the chemical industries, perhaps due to the comparative vagueness of these, since they do not deal with measures as tangible as in other industries, these principles have been slow to be applied. But they have been applied in some chemical industries, and those are the money-making ones, prospering even though there may be very heavy competition and a very small margin of profit.

Niagara Falls, Canada.

American Vanadium Facts is the title of a new and neat house organ issued by the American Vanadium Company, of Pittsburgh, Pa., miners of vanadium ores and manufacturers of "Amervn" ferrovanadium. The first issue, which has just been received, contains articles on general properties of vanadium and ferrovanadium, on vanadium steel forgings, on vanadium steel governor pins and their endurance and on vanadium steel castings. The Union Steel Casting Company, of Pittsburgh, is reported as having obtained recently the following results with vanadium steel castings: Tensile strength, 123,090 pounds; elastic limit, 86,220 pounds; elongation in 2 inches, 10 per cent; reduction of area, 15.6 per cent. These figures were obtained on 34-inch blooming mill pinions. After a special heat treatment a coupon from these pinions gave 20 per cent elongation and 49.6 per cent reduction without material change in the tensile and elastic figures.

[2]When I speak here of efficiency, I generally mean the "scientific" efficiency, although in some cases, under practical conditions, it may be more economical to aim at what might be called the "commercial" efficiency. Undoubtedly in most cases the economical way of operating is trying to reach the upper goal which is the "scientific" efficiency. But under special conditions and in special processes, the aim at reaching a high efficiency may influence the quality of the product or the output to such an extent that it may be better to aim at an efficiency that has been established through practical working as being the most economical, and this may be called the "commercial" efficiency.

A French Plant for the Fixation of Atmospheric Nitrogen

In our February issue, pages 102 and 103, a brief description was already given of the new works of La Nitrogene Company in La Roche-de-Rame, Hautes-Alpes, France, using the Pauling process for making nitric acid and nitrates from air. A very full description of the same plant is given by JULES VANDERPOL in the January issue of *La Houille Blanche*, from which the following translation has been prepared.

Reactions.

The chemical reactions are summed up as follows: The reaction in the arc in the electric furnace is

$$N + O = NO \tag{1}$$

The gases which leave the electric furnace have a temperature of 900° C. to 1000° C. and contain 1 per cent to 1.5 per cent NO and 98.5 per cent to 99 per cent air. When this gas mixture is cooled to 600° C. the NO reacts with the oxygen in the air according to the equation

$$NO + O = NO_2 \tag{2}$$

This reaction is somewhat slow on account of the low concentration of NO in the gas mixture (the speed of formation being inversely proportional to the concentration of NO) and is complete only at a temperature of 130° C. It is, therefore, necessary to let the gas mixture remain for some time in the large-sized tower in which this reaction goes on. This is the object of the oxidation tower which follows the cooling apparatus.

There remains the absorption of NO_2. As a matter of fact the gas is really a mixture of NO_2, NO, N_2O_3 and N_2O_4, the N_2O_3 being formed by the reaction of NO_2 on NO and the N_2O_4 being due to the partial polymerization of NO_2 in the oxidation tower.

The gas is subjected to the action of water at a temperature near 30° C., the reaction being

$$3 NO_2 + H_2O = 2 HNO_3 + NO \tag{3}$$
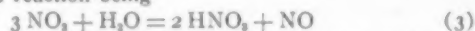
Secondary reactions also take place, the oxides N_2O_4 and N_2O_3 reacting with the water as follows:

$$N_2O_4 + H_2O = HNO_3 + HNO_2 \tag{4}$$
$$N_2O_3 + H_2O = 2 HNO_2 \tag{5}$$
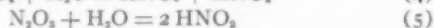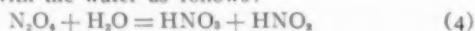
These reactions are immediately followed by the decomposition of nitrous acid.

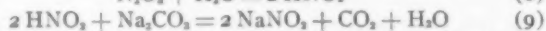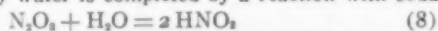$$3 HNO_2 = HNO_3 + 2 NO + H_2O \tag{6}$$

These reactions take place in the acid absorption towers. According to (3) only two-thirds of the NO_2 is changed to nitric acid, the remaining one-third being reduced to NO.
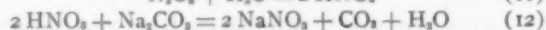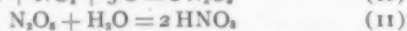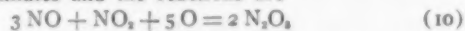
According to (6) only one-third of the nitrous acid is oxidized to nitric acid, the remaining two-thirds being changed to NO. Hence, a new oxidation of NO becomes necessary. This is the reaction between the peroxide NO_2 and oxide NO.

$$NO + NO_2 = N_2O_3 \tag{7}$$

The absorption by water is completed by a reaction with soda

$$N_2O_3 + H_2O = 2 HNO_2 \tag{8}$$
$$2 HNO_2 + Na_2CO_3 = 2 NaNO_2 + CO_2 + H_2O \tag{9}$$

The nitrite produced always contains a certain proportion of nitrate, since the gases when they leave the absorption towers do not contain exactly one molecule of NO for one of NO_2. The NO predominates and the reactions are

$$3 NO + NO_2 + 5 O = 2 N_2O_3 \tag{10}$$
$$N_2O_3 + H_2O = 2 HNO_2 \tag{11}$$
$$2 HNO_2 + Na_2CO_3 = 2 NaNO_2 + CO_2 + H_2O \tag{12}$$

These last reactions take place in the nitrite tower. These are the principal reactions. In reality they are still more complex and change with temperature, pressure, speed and quantity of gases in movement, etc.

La Nitrogene Company Works.

Electrical energy for the works at La Roche-de-Rame of La Nitrogene Company is generated from water-power, there being four turbine-driven main generators, each of 2000 hp. The energy is transmitted over an overhead transmission line

of aluminium of 600 m (2000 ft.) length to the furnace house.

The furnaces are installed in a hall (Fig. 1), 15 m (50 ft.) wide and 45 m (150 ft.) long. They are built of fire brick reinforced with steel and are arranged in groups of three. Their horizontal section is 1 m x 1.20 m (3 ft. 3 in. x 3 ft. 8 in.) and their height is 3 m (10 ft.). Their design is characterized by simplicity and robustness.

The design of the furnace is shown in Fig. 2 in several sections. Each furnace contains two vertical chambers $f f$, each chamber containing a pair of electrodes $e e$ of the form of a horn lightning arrester, as shown in the diagram at the right-hand bottom of Fig. 2. The electrodes are of steel, interchangeable and inside cooled by circulating water.

The arc between the two electrodes is blown upward into the form of a large sheath 60 cm to 70 cm (24 in. to 28 in.) high by means of hot compressed air, which is blown into the furnace through the tuyère t at a speed of 400 m per second. To permit the air to rise between the electrodes, the latter
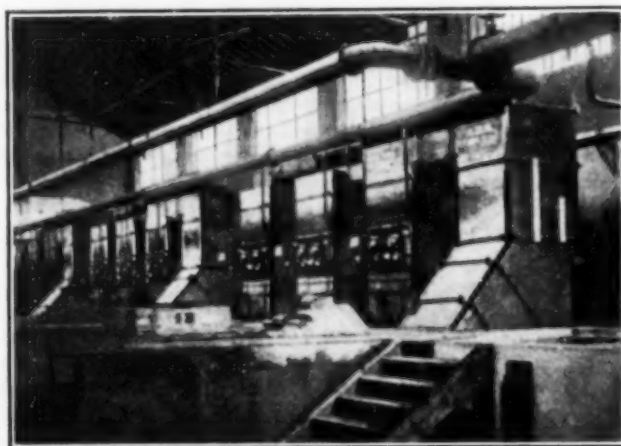
FIG. 1.—FURNACE HALL.

should not be too near together. But the distance between the two lower ends must also be sufficient to light the arc. To overcome this difficulty Pauling uses auxiliary electrodes c ("couteaux d'allumage") in form of thin copper blades, the ends of which can be brought near together (2 mm to 3 mm or 80 mils to 120 mils) to light the arc again if by accident it should be extinguished.

i are insulators, f is the passageway through which the cool air enters, s is the exit of the gas mixture produced. The wall which separates the two arc chambers from each other contains in its center another channel u by means of which a cold gas mixture is fed to the upper portion of the arc flame. This gas mixture ("umlaufluft" or circulating gas) is taken from the gases which have already been subjected to the reaction and have been cooled in their passage through the cooling apparatus. The "Umlaufluft," therefore, serves to cool the gases coming from the arc, without diluting their content of nitrogen oxides. This "Umlaufluft" is not indispensable for the satisfactory operation of the furnace, as the plant has worked satisfactorily without the "'Umlauf" being in use.

The copper blades forming the auxiliary electrodes last in the average 20 hours and can be replaced in a moment. The main electrodes last 200 hours, as they are internally cooled.

An opening in the exit passage s of the gases permits the introduction of a pyrometer for measuring the temperature and of a pressure gage to control the fan which sucks the gases to the cooling apparatus.

Each furnace has two arcs in series. The 50-period, 6000-volt, three-phase currents supplied from the power plant are used directly. The furnaces are single-phase and the three phases of the three-phase supply are connected to the three sets of furnaces in each group, respectively.

The electrical accessories are two self-inductance coils, a transformer used in starting the arc and a rheostat, all being placed in front of each furnace.

Nine furnaces, each of 600 kw, are in normal operation, but the installation of 1000-kw furnaces is contemplated, as they are more stable in operation and have a higher efficiency.

The air supplied to the furnaces comes from a 250-hp turbo-compressor running at 3000 r.p.m. The air is preheated in a preheater built of metallic tubes, the heat in the gases coming from the furnace being used to preheat the gases which go to the tuyères.

SECTION AB   SECTION EF

SECTION CD
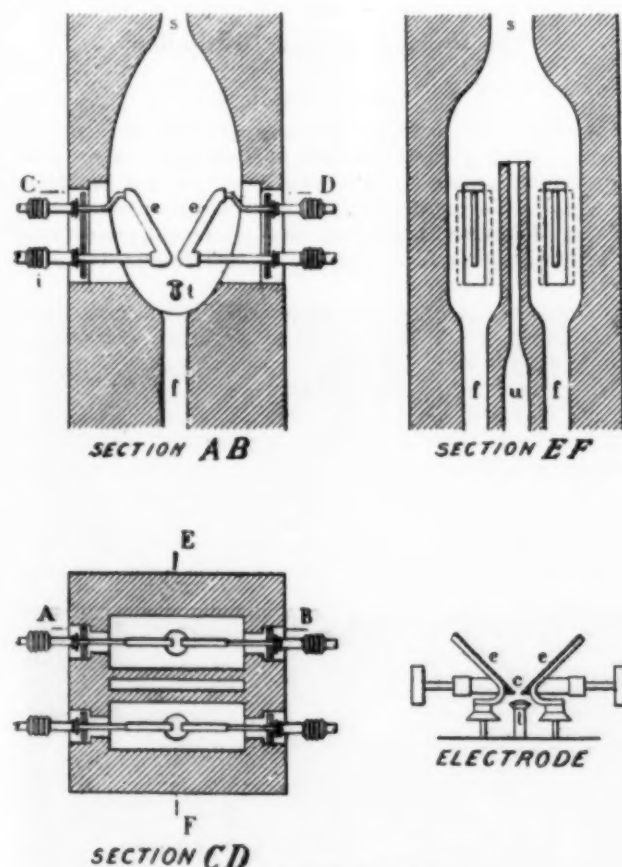
ELECTRODE

FIG. 2.—SECTION OF FURNACE.

Fig. 3 is a diagram of the electrochemical plant. B is the furnace house, E the preheater, F the groups of furnaces, D the repair shop and laboratory, R the cooling towers, G a chimney, O the oxidation tower, N nitrite towers.

H is the absorption shed containing the absorption towers A_1, A_2, A_3, A_4, A_5 and the concentration apparatus C_1 and C_2, while the acid is stored in M.

The gases coming from the electric furnace contain 1.15 per cent to 1.50 per cent of NO and have a temperature of 900° C. to 1000° C. They are first passed through the preheater E, where they give off some of their heat. This is important from the viewpoint of energy economy.

The gases are then passed through the cooling towers R. These two towers are alternately in operation. They are 5 m (16 ft.) in diameter and 12 m (40 ft.) high and are filled with brick which offers a large surface to cool the gases. When the bricks of one tower R have become hot, the gases are switched over so as to pass through the other tower, while fresh air is passed through the first tower (natural draught being obtained by means of the chimney, which is 26 m, or 85 ft., high) and the brick in it is thereby cooled. Hence while the gases are cooled and the brick heated in one tower, the brick in the other tower is cooled by fresh air, and so on.

The oxidation of NO to NO_2 begins when the temperature

of the gases has sunk to 600° C. But this temperature is not yet reached in the cooling towers.

The gases are now sucked out of the cooling towers by means of a 15-hp fan which produces suction as far back as in the furnaces. By the fan the gases are driven into a large reinforced concrete tower, called the oxidation tower and shown in Fig. 4. It is 23 m (75 ft.) high, 10 m (33 ft.) in diameter and the thickness of the walls is 10 cm (4 in.).

Two lines branch off at this point. The first branch line represents the "umlauf" gas line through which part of the cooled gases is returned to the furnaces.

The second branch line consists of an aluminium pipe line, cooled with water, and this is put in service when the cooling by the towers has not been sufficient.

The oxidation tower (Fig. 4) is filled with acid-proof refractory brick. It is in this tower, in which the gases remain for a relatively long time, that the cooling of the gases is completed and the NO is changed to NO_2.

The absorption apparatus and concentration apparatus for the acid are placed in the shed H, in Fig. 3. This is 22 m (72 ft.) high and covers an area of 15 m x 30 m (49 ft. x 98 ft.).

The absorption of the gases by the water takes place in the five absorption towers A_1, A_2, A_3, A_4, A_5 (Fig. 3), through which the gases pass in the direction from A_1 to A_2 to A_3 to A_4 to A_5, while the water (gradually containing more and more acid) flows in the opposite direction.

Montejus, operated by compressed air, raise the solution to
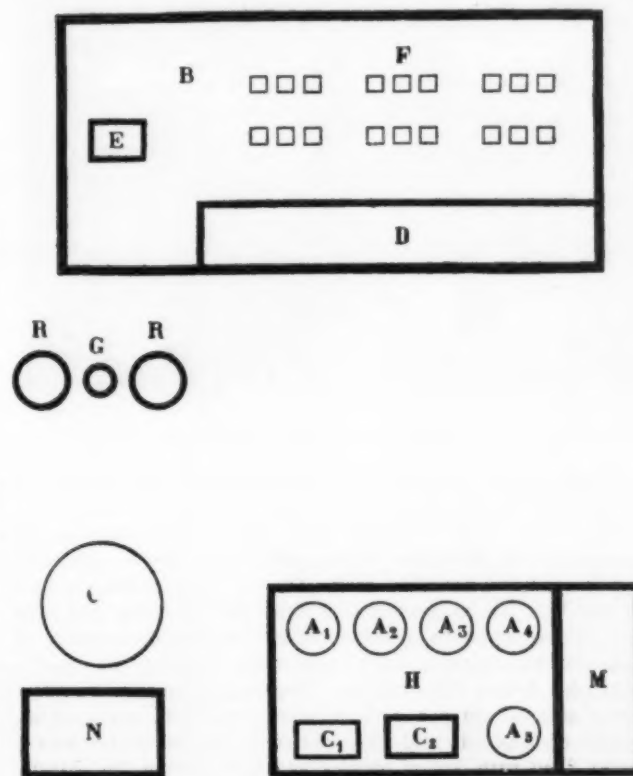
FIG. 3.—DIAGRAM OF ELECTROCHEMICAL PLANT.

the top of the different towers. Each tower contains 250 tons of acid-proof stoneware packings.

In general the concentration of the acid in the tower A_5 is 5° Beaumé, further 8° to 10° Be in A_4, 12° to 15° Be in A_3, 18° to 20° Be in A_2, and 25° to 30° Be in A_1, which corresponds to 35 per cent to 40 per cent of HNO_3.

From the absorption tower A_1 the acid is passed to the concentration apparatus C_1 and C_2 (Fig. 3). It is passed through a series of porcelain or fused-quartz vessels arranged in stairway fashion. While passing through the vessels the acid is

heated by direct contact with hot gases which come from the furnace. These gases are thus charged with water and nitric acid vapor. To condense the nitric acid the gases are passed through a cooling coil of stoneware which offers a very large cooling surface. The gases are then passed into the oxidation tower, where they mix with the gases coming from the furnaces.

The acid obtained by this concentration process contains about 50 per cent HNO_3 (about 36° Be) and it is possible to push the concentration up to 60 per cent (40° Be) by this process. But further than this it is not possible to go in this way, since the vapor produced has a concentration which increases with the concentration of the solution, and for a con-
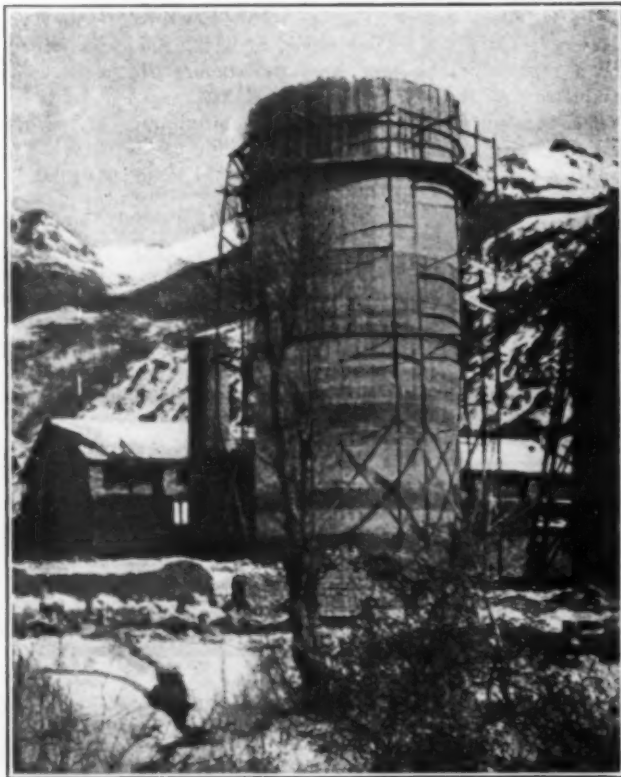
FIG. 4.—OXIDATION TOWER

centration of 66 per cent the vapor produced has exactly the composition of the liquid.

To obtain higher concentrations other means must be resorted to. At the Patsch plant an electrolytic process of Pauling is used (as described in his United States patent, noticed in our Vol. VI, 1908, page 300). But on account of the high cost of the apparatus, which requires considerable amounts of platinum, this method is not used in the French plant.

In the latter the following process is employed: The nitric acid, of 60 per cent, is mixed with two parts of its weight of sulphuric acid of 92 per cent, then introduced into a tower filled with Volvic packing and heated from the outside. In this way a nitric acid with a concentration of 98 per cent may be easily obtained. The sulphuric acid withdrawn from the bottom of the tower, which has been diluted by the absorbed water to a concentration of 77 per cent or 80 per cent, is concentrated and then used again.

The gases which pass out of the absorption towers contain NO and NO_2. They are passed through an acid filter in which the last traces of the acid are condensed. The gases then pass into the nitrite towers (N in Fig 3), when they are caused to react with a sodium carbonate solution. The sodium nitrate solution obtained has a concentration of 20 per cent, and is then submitted to evaporation. The hot furnace gases are

used for this purpose. The nitrite crystals obtained are white and contain 95 per cent nitrite and 3 per cent nitrate.

The sodium carbonate solution used in this part of the process is the only raw material employed in the plant besides atmospheric air and water.

As to the efficiency it is stated that Pauling guarantees a yield of 60 grams of 100 per cent acid per kw-hour of electrical energy, measured at the entrance of the electric transmission line into the factory. Pauling also guarantees that the cost of the electrochemical plant proper is not more than 120 francs ($24) per kilowatt.

The Process of Zinc Distillation

By George A. Wettengel.

The experiments that have been in progress for the last year at one of the zinc smelting plants in Kansas with a rotatable zinc smelting furnace (United States patent 901,405; this journal, Vol. VI, November, 1908, page 457) will be of interest, as this type of furnace has many advantages over the present type of stationary furnace in labor saving and increased life of retorts.

The present type of furnace necessarily requires much hard manual labor and the chief object of my improvements is to provide a furnace adapted to be mechanically operated. This is accomplished in the following manner:

Fig. 1 is a front view of the furnace in operating position; Fig. 2 shows the furnace in the charging position. The furnace consists of a steel shell, with two tires supported on rollers. one of the tires has a gear attached, engaging the driving mechanism by which the furnace can be rotated to any desired position. The inside of the shell is lined with tile, with suitable shelves for suporting the retorts. The pipes supplying
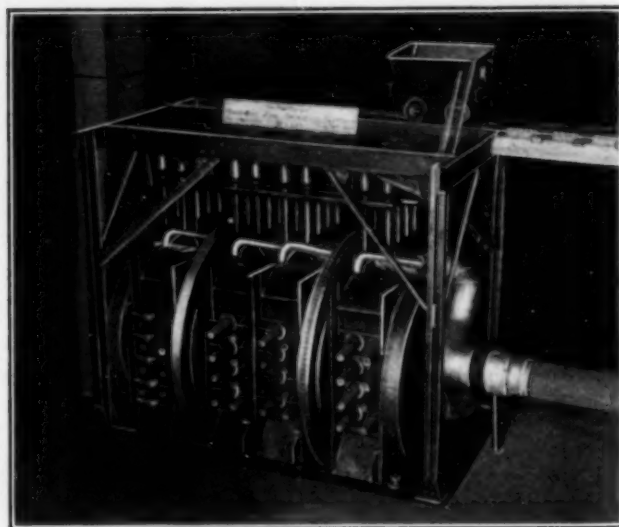
FIG. I.—ZINC FURNACE IN OPERATING POSITION.

gas and air to the burners are attached to and rotate with the furnace.

Above the furnace is the charging floor, containing hoppers each just large enough to hold the ore mixture for one retort, with shut-off slides and telescopic spouts that are lowered to the top of the retorts so that all of the ore mixture goes into the retorts. Below the furnace is a large hopper for the residues.

The ore mixture is dumped onto the charging floor, each hopper filled, and then the furnace is rotated upward so that the retorts are vertical with their open ends in line with the hopper spouts. These are now lowered and slides opened, whereupon the ore mixture falls by gravity into all of the retorts

simultaneously. Then the furnace is rotated downward so that the retorts are now in a horizontal or any position which may be desired for the destillation.

The condensers are put on, luted, stuffed and vented. After completing the distillation process the condensers are removed and the furnace again rotated so that the retorts are vertical, but have now their open ends downward. The residues then fall out by gravity into the hoper under the furnace.

The furnace is then rotated again so as to bring the retorts into a horizontal position and is then cleaned of adhering loam and any remaining residues and then recharged as before. But instead of rotating it to its first operating position it is now rotated with the open ends of the retorts pointing in the opposite direction. The retorts are now 180° from their first operating position. This inverts the retorts so that the bottom of each is used as the top, and vice versa. This brings the slags to the top of the retort chambers, which it melts and drips down onto the distilling ore mixture and is discharged with the residuum.

This inverting of the retorts makes them practically self-cleaning, almost entirely avoid scraping, and increases their life by using two sides. It keeps them practically straight.
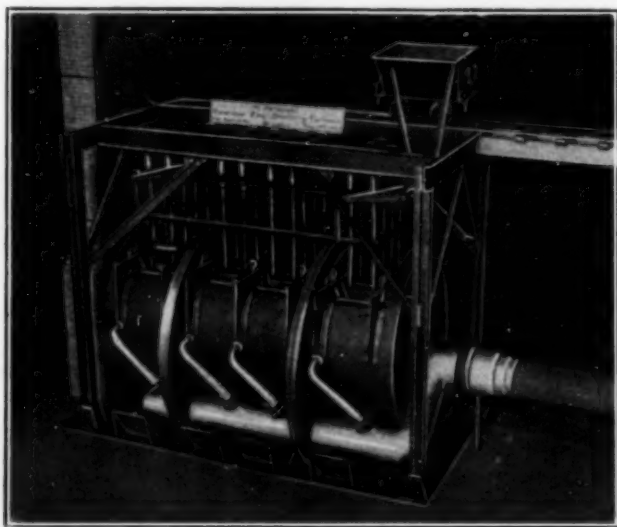
FIG. 2.—ZINC FURNACE IN CHARGING POSITION.

This method avoids the present danger of cracking the retorts and of the slags perforating them.

Distribution of Charge and Dryness of Ore Mixture.

To charge the present type of furnace the charger stands in front of the white-hot retorts facing the charging car which contains the ore mixture and shovels the contents of the latter into the mouths of the retorts, filling them one by one with a semi-cylindrical scoop, requiring eight or nine scoopfuls to fill a retort, the amount depending on the force and skill with which it is thrown in by the charger. This slow process is not only hard, laborious and unhealthful work, because of the intense heat, but also unsatisfactory as all of the retorts do not receive the same amount of ore mixture, it being packed unevenly within the retorts.

The ore is charged into the retorts wet enough to stick together, requiring about 15 lb. (2 gal.) of water per retort. This not only chills the retorts and absorbs heat to distill off the water, but also retards the process of zinc distillation. The steam generated by the intense heat frequently expels the entire charge before it can be vented (commonly called spiessed).

With my rotatable furnace each retort is charged simultaneously from individual hoppers from the charging floor above with a predetermined amount of ore mixture which is uniformly distributed throughout their length. This greatly reduces the time of charging, dispenses with the chargers,

necessarily decreasing the cost of operation, increases the time for the distillation process and also increases the capacity of a furnace.

The ore mixture is charged dry, necessarily a more rapid and thorough distillation of zinc is obtained with a considerable saving in fuel consumption without the present danger of chilling the retorts or expelling the entire charge. Thus a more rapid and thorough distilling process is attained with an increased life of the retorts by dry charging.

Sagging of the Retorts.

Since the retorts in the present type of furnaces are only supported at their ends, they gradually sag and distort, not being strong enough to preserve their shape and successfully support the weight of the contained ore mixture and resist the intense heat to which they are subjected during the zinc distilling periods.

The compressive stresses produced in the upper half of a retort by the weight of the contained ore mixture is safely resisted while the bottom half is in tension, the stresses of which the material cannot safely resist as it has a very low tensile strength.

The retort continues to sag until it fails by cracking across the bottom. This not only requires replacing the retort, but occasions large losses of zinc.

With a rotatable furnace any tendency of the retorts to sag, distort, crack or lose their shape from the weight of ore mixture and the intense heat to which they are subjected during the process of zinc distillation is resisted by inverting them for each distillation process. This not only keeps them practically straight, but also avoids the present danger of losing their shape and cracking, necessarily increasing their life and the zinc recoveries.

Slags Perforating the Retorts.

In the present type of furnaces the tops and sides of the retorts are not seriously affected by the repeated distillations, the bottoms, however, are usually attacked by the corrosive slags and perforated, particularly when the ore treated contains a large percentage of iron, manganese or lime. After a retort has been perforated the slags will drip on top of the retort lying below, which will also be perforated, but from the outside. This not only occasions large losses of zinc, but necessitates replacing the retorts.

In a rotatable furnace the slags formed and adhering to the bottoms of the retorts during the process of zinc distillation are brought to the top by inverting them for the next distillation process. The bottom being on the top and vice versa. This adhering slag gradually drips off of the retort and drops on top of the smelting ore mixture and is discharged with the residuum. This not only prevents all the slags from accumulating on the bottoms of the retorts, which reduces their capacity and efficiency, but prevents the corrosive slags from perforating the retorts as in the present practice.

After rotating the furnace downward for discharging the residue it is left in this position for several minutes, during which time small pieces of slag fall out, also burning iron which can be distinguished by bright sparks similar to the sparks from a piece of iron brought to a welding heat. These sparks of burning iron continue to drop from the top of the inverted retorts after they are brought to a horizontal position. This increases the life of the retorts by removing most of the iron and slag, which corrodes the retorts.

Uniformity of Temperature.

In bringing the present type of furnace to the proper temperature for distilling the ore mixtures in the lower tiers of retorts, the upper tiers are subjected to a higher temperature than is required. This intense unequal heat has an injurious effect on the upper tiers of retorts.

In my method the rotatable furnace with its retorts is reversed each day to overcome the unequal heating of the top and bottom tiers of retorts. This reversing brings the retorts

from the top, or hottest, to the bottom, or coolest, part of the furnace each day, thereby prolonging their life.

Condenser Loam.

In the present type of furnace the conical condensers are inserted with their large ends projecting into the open ends of the retorts about 1 in. and lying on the bottom of the latter, thus forming a crescent-shaped joint with an opening at the top of about 1 in., which must be luted up air-tight with loam. After the condensers are removed the loam adhering mostly to the upper half of the retorts must be removed each day to again admit the condensers. This is accomplished with a heavy
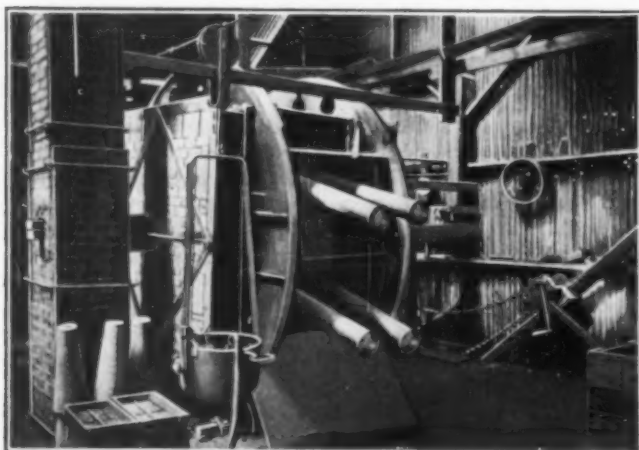

FIG. 3.—EXPERIMENTAL FURNACE IN OPERATING POSITION.

bar, commonly called a bumper, with which the workman bumps off the adhearing loam frequently, chipping off small pieces of the retort with it, until they become leaky or breaking them so that they must be replaced. In a rotatable furnace the retorts are inverted each day, bringing the loam on the top one day and on the bottom the next and vice versa. This greatly reduces the present danger of chipping or breaking the retorts in removing the loam.

Metal Drawing.

In the present type of furnace the metal is drawn off by inserting an iron scraper into the ends of the condensers and scraping out the loam stuffing and the liquid metal into a ladle attached to a crane conveniently supported on a truck which travels on a track parallel with the working face of the furnace. When the ladle is full of metal it is swung out from the furnace, the top skimmed off and its contents poured into molds. Occasionally a condenser is knocked loose accidentally whereby the liquid metal rushes out covering the metal drawer, often seriously burning him. This is very hard, dangerous and unhealthful labor on account of the intense heat and fumes escaping from the ends of the condensers.

In my method the metal is drawn off by rotating the furnace to an angle of about 15 deg. below the distillation position, whereupon the metal rushes out of all of the condensers simultaneously into a trough extending the length of the working face of the furnace and then collects in a ladle at the end. The contents of the latter is then poured into molds. This not only requires a fraction of time to draw the metal as compared with the present method, but greatly reduces the hard, dangerous and unhealthful labor, as the operator is away from the intense heat, fumes and liquid metal issuing from the condensers.

Agitating the Ore Mixture.

I rotate my furnace upward after each drawing of metal so that the ore mixture falls by gravity to the rear ends of the retorts. I then continue rotating the furnace until the retorts are again brought to the distillation position, but inverted. By this occasional agitation of the ore mixture the particles of ore

and carbon will be more thoroughly mixed and brought into more intimate contact with new surfaces whereby a more rapid and thorough distillation process is attained. This not only increases the recoveries of zinc, but also reduces the time required for the process of zinc distillation.

Composition of Residue.

In the present type of furnace the ore mixture is not uniformly distilled, necessarily the residues at the open ends of the retorts are rich in zinc because the ore mixture does not receive heat enough to thoroughly distill it. Two in. or 3 in. of this residue (called sampling) is scraped out of the open ends of the retorts and is mixed with the ore mixture to be charged for the next distillation process. This not only increased the labor, but reduces the amount of fresh ore mixture that can be charged into the retorts.

By rotating my furnace after each drawing of metal so that the retorts are brought with their open ends upward the ore mixture falls by gravity to the rear ends of the retorts, thereby bringing the ore mixture from the open ends of the retorts where it receives insufficient heat to the rear ends where it will be thoroughly distilled. This not only greatly reduces the labor and increases the amount of fresh ore mixture that can be charged into the retorts, but increases the recoveries of zinc.

New Retorts.

In the present practice when a new retort is placed in a furnace it is not charged the first day, this time being allowed for burning and glazing the retort. A retort is replaced 12 times a year, necessarily losing 12 days per year by not being charged. In a rotatable furnace the retorts are replaced 2 4/10 times a year, necessarily losing only 2 4/10 days per year for burning and glazing. An increase of 9 6/10 days per year per retort capacity of a furnace, or an increase of 9 7/10 per cent in capacity. This greatly increases the capacity of a furnace without any additional labor.

Heat Transmitting Efficiency.

In the present type of furnace with its stationary retorts the heat transmitting efficiency decreases as the slags accumu-
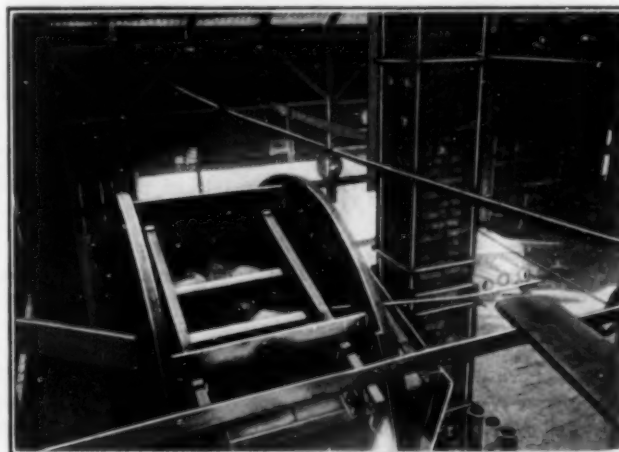
FIG. 4.—CHARGING POSITION OF EXPERIMENTAL FURNACE

late on the bottom of the retort chamber until it is from 3 in. to 4 in. thick during its 30 days' use, necessarily considerable more fuel is required to bring it to the proper temperature for the distillation process than for a new retort.

In a rotatable furnace with its inverting and self-cleaning retorts the slags formed on the bottom of the retort chamber during the distillation process one day are brought to the top of the retort chamber by inverting them for the next distillation process, whereupon the slags drip off onto the smelting ore mixture and are discharged with the residues. These slags corrode the walls of the retort, decreasing their thickness and

necessarily greatly increasing their heat transmitting efficiency.

Capacity of a Retort.

In the present type of furnace with its stationary retorts the slags gradually accumulate on the bottom of the retort chamber until it is from 3 in. to 4 in. in thickness, necessarily greatly reducing its capacity.

In my rotatable furnace with its inverting and self-cleaning retorts the capacity does not decrease, but remains the same until replaced.

In my rotatable furnace the ore mixture is charged dry. It is possible to charge about 10 per cent more ore mixture dry than wet as it fills the retorts more compactly.

Temperature of Furnace While Charging.

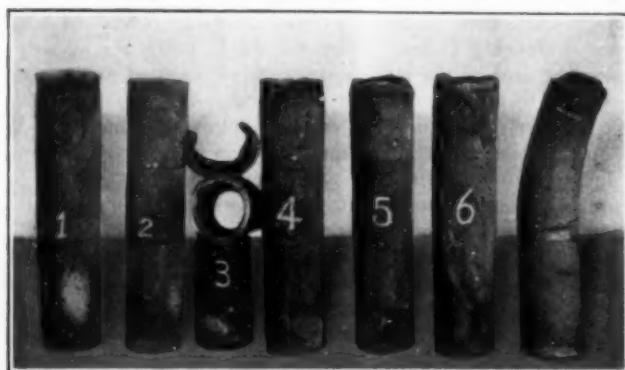In the present type of furnace the heat is practically shut

FIG. 5.—RETORTS.

off for several hours during the charging operation, necessarily greatly reducing the temperature of the furnace at a period when it is necessary to bring the cold and wet ore mixture in the retort to the distillation temperature as quickly as possible.

In my rotatable furnace the temperature is not reduced except as required during the distillation process. All the retorts are charged simultaneously from individual charging hoppers from above with dry ore mixture, therefore, greatly reducing the cooling off period while charging.

Use of Metal Tools.

In my rotatable furnace there are no metal tools used in drawing the metal except the last drawing. This not only prevents breakage and abrasion of the condenser, but greatly reduces the absorption of iron from the metal tools used and a purer metal is obtained.

Fig. 3 is a front view of the experimental rotatable furnace in the operating position. The furnace is rotated as required by means of a wrench and link belting which engages sprocket wheels on the shafts of two of the supporting rollers. It has six ordinary retorts 8 in. in diameter by 48 in. long inside dimensions. To maintain the temperature as nearly uniform as possible pyrometric cones were used inside of one of the retorts (No. 2) as an aid in regulating and recording the temperature. Therefore, only five of the retorts were charged. The furnace was charged in the usual way for several months with such excellent results that I decided to try charging it from the top to demonstrate its practicability.

An inclined runway and platform was constructed to charge from. The platform was on a level with the working face of the furnace when in the charging position. After the residues were discharged, the furnace was rotated so that the retorts were in a vertical position with their open ends upward (see Fig. 4).

It was now charged from above by wheeling the ore mixture up the incline runway onto the platform, then shoveling it into the vertical retorts, filling them one by one with dry ore mixture instead of wetting it as in the present practice. After all

of the ore mixture was charged, the last retort was only about one-third full, thereby demonstrating that considerable more dry mixture could be charged into the retorts than of the wet.

The furnace is now rotated to the operating position and the distillation process continued similar to the best present-day practice. The top charging was discontinued after charging about one week as it was hard work to wheel the ore up the steep incline runway.

Fig. 5 shows the six retorts after they were removed from the furnace, having been in 167 days. These retorts are practically as straight as on the day they were put into the furnace. Compare these with the crooked retort to the right of No. 6, which was taken from one of the ordinary type of furnaces after being in use less than one month.

Retort No. 1 was cracked accidentally in putting it in the furnace. It was charged 81 times. Charging was then discontinued as the crack was opening up and losing zinc.

No. 2 was never charged. Pyrometric cones were put in this retort to regulate the temperature.

No. 3 was charged 151 times when a small hole was discovered in one side.

No. 4 was charged 167 times and was still in excellent condition.

No. 5 was charged 143 times when a small hole was found in one side.

No. 6 was still in excellent condition after being charged 167 times.

Fig. 6 is a view of retort No. 4 cut in two, vertically, showing it to be in excellent condition after being in continuous operation for 167 days. There was very little slag in it, and very little corrosion had taken place as the walls of the retort were from $\frac{3}{4}$ in. to $\frac{7}{8}$ in. in thickness. None of the retorts were perforated by the slag.

This is a remarkable showing when compared with the life
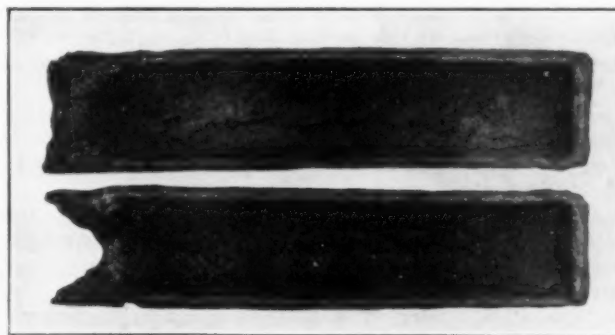
FIG. 6.—RETORT NO. 4 CUT OPEN.

of retorts in the usual type of furnace, which average about 30 days.

Joplin ore was used in these experiments with 4 per cent to 5 per cent iron.

The average loss was 8 per cent. This is an excellent showing considering the small size of the furnace and the difficulty in maintaining the correct temperature.

After the retorts were removed from the furnace a new set was put in, which were in continuous operation for 154 days. The retorts were still in good condition at this time.

St. Louis, Mo.

Pure radium has been prepared by Madame Curie, who announced her success in September, 1910. The production of radium salts has not increased greatly, and the cost of obtaining them, either by purchase or loan, is still excessively high. Prices are quoted at about $100 per milligram. Radium is loaned in Paris for scientific purposes at a cost of $100 to $200 per day for 100 milligrams. The production in France in 1910 was 1.92 grams, and was sold for about $150,000.

Recent Progress in Calorimetry.

The Real vs. the Supposed Errors.

By Walter P. White.

In pure science and in its technical applications an important place belongs to calorimetry, the measurement of quantities of heat, of heat energy, of heat as distinguished from temperature. It is well known that nearly all large users of coal or other fuel no longer buy by weight alone, but by fuel value, thus actually paying for heat, the thing they are really after. The fuel testing made necessary by this practice is probably the most extensive and familiar use of the calorimeter, but nearly every physical or chemical process is accompanied by a heat effect whose determination is necessary for complete knowledge, and heats of fusion and vaporization, variations of specific heat with temperature and pressure, and heat effects accompanying solution, dilution and other chemical processes occupy prominent places in the literature of their respective subjects.

In spite of its importance, calorimetry has been singularly backward in development and has long been considered to be a subject wherein high accuracy was probably unattainable. Within the last five years, however, a great improvement has taken place. A careful study of the various sources of error—which in itself furnishes a good example of the value of systematic scientific methods—has shown that previous practice was largely based on notions and estimates widely at variance with fact and has rendered possible a progress based on knowledge. In considerable part, however, it is only fair to say the improvement has been due merely to the application of a little common sense to practices which rested on nothing but the thoughtless acceptance of traditions handed down from earlier and cruder days. The net result is that the measurement of heat in a calorimeter may now usually be made more accurate than the necessary associated determinations. For instance: Weighing is well recognized as one of the most accurate of physical determinations. In determining the heat of combustion of many substances the error may now be no greater than the unavoidable error in weighing the sample.

The calorimetric method in which this progress has been most conspicuous is the most common and familiar one, often known as the method of mixtures; it alone will be regarded in the present paper.

In principle the mixtures method is exceedingly simple. Heat is added to a vessel of water (or other fluid) and the resulting temperature rise is measured. The heat is then given as simply the product of temperature rise by the heat capacity of the water and calorimeter. The numerous complications occurring in practice all arise from one cause—the loss of heat which begins as soon as the water is heated. This (1) necessitates a correction, the "cooling correction," for the heat lost; (2) requires experimental arrangements which increase the difficulty of dealing with evaporation; (3) calls for stirring, and the stirring, if effective, produces appreciable heating; (4) makes it necessary to take observations of time, since the temperatures are continually changing; (5) gives opportunity for error if in the various changes any parts of the system fail to follow the change quickly enough; opportunity, that is, for "lag" errors of various sorts.

Of these complications the cooling correction has generally been counted the chief. Omitting details for the present, the principle of the cooling correction is as follows: The heat loss can be found if we know two things—the temperature of the calorimeter, and the way in which the heat loss depends on that temperature, or the "cooling constant," as it is called. Observations on the calorimeter temperature are easily made during the heat transfer. Observations of the cooling rate, made before and after the transfer period, define very accurately the "cooling constant" for the particular set up and the particular half-hour of the experiment. A simple calculation then gives the correction.

This procedure, in the form just outlined, evidently assumes that the environing temperature remains constant, since this also affects the cooling of the calorimeter. To promote this constancy the calorimeter has usually been surrounded by a water jacket, except at the top, which is left exposed to the air of the room. This arrangement is evidently far from perfect, for the jacket temperature also may vary, and the influence of the room is not wholly excluded. And, in fact, the changes may easily be of sufficient amount to be a source of error. The remedy, however, is easy and simple; it is to make the jacket surround the calorimeter completely and then measure the temperature of the jacket and allow for any changes. This gives directly the difference of calorimeter and jacket, which is really the quantity on which the heat loss directly depends. This method is one of the recent improvements and has been adopted independently by several different workers. If certain slight lag effects are also guarded against, the cooling then depends on simple, definite conditions which are thoroughly known. Since the whole correction is only a few per cent of the total heat quantity measured, there would seem to be no reason why it should cause appreciable error.

There has been, nevertheless, a widespread opinion that the cooling correction error is the largest in calorimetry, and that this condition is almost unavoidable. Indeed, this belief has probably gone far to discourage attempts at reducing the other errors. No adequate experimental evidence appears ever to have been offered in favor of this notion as to the hopelessness of the cooling correction, and lately decisive evidence has been obtained of its falsity. For instance: In a recent series of over 100 calorimetric determinations at the Geophysical Laboratory the time, the initial temperature, etc., were varied among the various observations so as to make the relative magnitude of the cooling correction vary within wide limits. Although the average accidental error was only from 20 to 40 parts per 1,000,000, and most of that was evidently due to the temperature measurement, yet there was no sign of any error due to the cooling correction. With proper precautions, therefore, the cooling correction error is not only not large, it is imperceptible. The hopelessly uncertain cooling correction is a myth.

With *evaporation* the case is altogether different, and irregular evaporation is probably responsible for much of the irregularity attributed to the cooling correction. There are cases where, in work intended to be specially accurate, the published data show that the heat loss by evaporation was often quite as great as that due to the regular cooling. Evaporation depends on a condition, the saturation of the air, which is at once very variable and hard to determine. Hence, as a rule, the only satisfactory way to regulate evaporation is to prevent it. Fortunately, this is not difficult.

Two ways are available. One, of course, is simply to cover the calorimeter tightly. The other is to cover it loosely, or not at all, but to keep it below the temperature of the jacket. In that case the air within the calorimeter chamber very soon becomes saturated at the temperature of the coolest body in it, the calorimeter, and evaporation then ceases. Of course, there will be a little more evaporation when the calorimeter is warmed, but the total amount of this can be kept small by restricting the size of the calorimeter chamber. For instance, if a 2-liter calorimeter is heated 2 deg. and the air space around it is only 1 liter, the heat abstracted by the extra evaporation will not be far from three calories, or about 0.8 per mille of the total heat measured. If a correction is applied for this, the *error*—that is, the uncertainty—will be only a few tenths per mille. Of course, this assumes that the chamber is well inclosed all the time, that its walls are thoroughly dry, and that care has been taken to keep well above the dew point. The evaporation of small drops of water from the *outside* of the calorimeter is especially productive of error on account of its great uncertainty. The remedy is obvious.

The *heat produced by stirring* is much less serious than the effect of evaporation, but may still cause appreciable error if improperly treated. This is because the heat production in-

creases at least as fast as the third power of the speed of stirring, so that a stirring rate only a little in excess of what is necessary may cause a rather large surplus of heat. Previous practice has almost universally been widely astray in this matter. For instance, Richards and Burgess have shown that stirring has nearly always been insufficient. The opinion has also been common that reciprocating stirrers, with horizontal vanes moved up and down, give less heat for equal efficiency than screw propellers. The opposite is the case. The greatest objection to the reciprocating stirrer, however, is the increased evaporation it usually causes.

The object of stirring, of course, is to secure inside the calorimeter uniformity of temperature; just how great this uniformity must be will depend on the accuracy sought. The heat of stirring will not be a source of error so long as it is constant, for it can then be allowed for, but its variations, due to variation in the speed of stirring, will cause error, and a variation of 1 per cent in the rate will cause a variation of 3 per cent in the heat. Of course, by regulating the speed closely enough it will nearly always be possible to avoid appreciable heating error, but what is wanted practically is to secure uniformity of temperature without making careful regulation necessary. The ideal calorimeter would be accompanied by a statement of the proper speed of stirring for any given error due to uneven temperature, and of the heat production at that speed. The allowable variation in speed could then be found at once. As it is, the user will generally have to determine these quantities for himself.

(1) The greatest error from lack of uniformity in temperature is usually due to the lag of the surface of the calorimeter behind the center while heat is being added; this is easily determined if a thermo-element can be used. (2) The heat of stirring can easily be found by observing for alternate periods of 10 minutes (say) with the stirrer first in action, then still, etc., and the calorimeter very near the temperature of the jacket.

In one calorimeter (with propeller) of 1½ liter capacity, stirring, certainly effective enough to reduce the error from uneven temperature below 0.025 per mille, raised the temperature about 0.001° per minute. This would demand a speed of stirring constant to 6 per cent for an accuracy of 1 per mille with a 2° rise and 10-minute interval. This result may be useful as a rough guide for those who are not in a position to make thermoelectric observations, but who can, of course, determine the heat of stirring.

In this case the error from heating would ordinarily greatly exceed that from uneven temperature, hence slower stirring would usually be better. With stirring one-third as fast the error from uneven temperature would still probably not exceed 0.08 per mille (for the same time and temperature intervals), and the error from heating would be no larger than this, even with a speed varying 10 per cent. On the other hand, if the speed were to be doubled, the heating would be 0.1° in 10 minutes, and the accuracy would be very limited, even with a stirring speed regulated to 1 per cent. This shows very clearly the disadvantage of a speed even a little too great. It should be added that the *error* from uneven temperature here is (arbitrarily) taken as one-sixth the actual temperature difference. The calorimeter here referred to was especially designed for facility in stirring; there were no dead spaces where the water could linger, and the flow of the circulating water was not throttled at any point.

The *timing* of the observations should never cause appreciable error. For, let K be the cooling factor of the calorimeter— that is, let the calorimeter cool in one minute the fraction K parts of its excess temperature above the jacket. K, for ordinary calorimeters, is not very far from 0.003. Hence a calorimeter, starting at jacket temperature and heated by any amount, will cool about 1/330 of that in each minute, or 50/1,000,000 of it in one second. As the timing can easily be done to half a second, the probable error will be less than 25 parts per 1,000,-

000. (If the calorimeter does not start from the jacket temperature the error will not be very different.)

The relation between time error and proportional temperature error thus depends on the cooling rate of the calorimeter. This relation is important, for it also holds for all lags.

The *lag effects* are rather complicated, but fortunately the only serious ones are easily preventable.

The one most prominently advertised thus far is the thermometer lag. A mercury thermometer will often lag ten seconds or more behind the fluid surrounding it, thus making its readings higher than the real temperature of a cooling calorimeter. Ten seconds, we have just seen, corresponds to a temperature error of 0.5 per mille. The thermometer lag, however, has lately been shown to involve no error, because it enters both in the cooling correction determination and in the final temperature, and enters oppositely in the two, so that *if the same thermometer is used throughout* the two opposite effects are equal and cancel each other. The simplest way to demonstrate this is to consider that a uniform lag on *all* the readings amounts to the same thing as reading them correctly, but a few seconds earlier each time—which, of course, would introduce no error. (For a more complete demonstration those interested may be referred to several articles on calorimetry in the *Physical Review* for November and December, 1910. These articles also supplement the present paper in other respects.)

The unavoidable lag effects are (1) the lag of the cooling itself: as the calorimeter is heated it takes a little time (about two seconds) for the air currents to get started around it. (2) The very trifling lag of the projecting metal parts of the calorimeter. (3) The lag of the surface behind the center as the calorimeter is heated. This is due to the time required for the heat to pass outward through the water, and depends on the rate of stirring. It may be, under proper conditions, from three to nine seconds. The total effect of these unavoidable lags, therefore, may be from five to eleven seconds, or from 0.25 to 0.5 part per mille. But these lags also have this property: their effect is independent of the manner of heating, whether sudden or slow, but is always proportional to the temperature rise. Their effect, therefore, is precisely equivalent to that of a slight change in the heat capacity of the calorimeter. Hence, if a calorimeter has been calibrated, and is not afterward changed, the error due to these lags will be altogether inappreciable, otherwise results will (as far as their influence is concerned) be consistent, but subject to a systematic error about equal to the present uncertainty in the specific heat of water.

Two remaining effects are perhaps better regarded not as lags, but rather as cases of variable environing temperature. These are the effects of non-metallic supports or projections, and of covers not touching the calorimetric fluid. Such bodies warm up gradually after the calorimeter is heated, and during all that time the heat flow into them is changing in an unknown way. For instance, calorimeters have been known to be set on a solid plate of hard rubber, a gratuitous introduction of error so needless as to be quite inexcusable. A safe rule is to make all non-metallic supports so small that their total heat capacity is negligible, which is easily done. The stem of a glass thermometer, however, may introduce a slight error through its varying temperature. Uncertainty in the temperature of the cover can be avoided by depressing the center of the cover so that a considerable part of it touches the water.

The determinations at the Geophysical Laboratory, mentioned above, were, of course, subject to error from evaporation, stirring and lag. Hence those results show that accidental errors from *all* these causes taken together may be made quite inappreciable.

The chief *unavoidable calorimetric error*, then, is just where it would be if a perfect heat insulator existed—that is, in the temperature measurement.

The rise of temperature employed in calorimeters is seldom over 4 deg., and often less than 2 deg. The most sensitive mer-

cury thermometers are rarely read closer than to 0.001 deg. Now, even with perfect judgment on the observer's part, and perfect behavior of the instrument, there is evidently always a possible accidental error of half the smallest unit recorded. But two to four accurate thermometric readings enter into a single determination. Hence, the unavoidable accidental thermometric error may be as high as 1 per mille, altogether aside from imperfections in the instrument or the observations, which will ordinarily make the error still larger.

Two remedies are possible. The first is to increase the *precision* of the thermometric measurements. This has hitherto called for electric thermometers. These, of course, are complicated in comparison with mercury thermometers, though they also have some decided advantages besides the increased precision. There is, however, a second and very easy method of reducing the thermometric error, and that is to increase the temperature interval by diminishing the amount of water heated or by increasing the amount of heat. This method runs contrary to a generally accepted opinion which insists that small temperature intervals are necessary for accuracy. But the reasoning on which this opinion is based appears upon examination to be rather unsatisfactory. That reasoning, briefly, is as follows: The heat loss from a calorimeter is not proportional to the excess of temperature above the environment, but increases more rapidly than it. If heat loss is plotted against temperature difference the result is a line which curves upward. Now this curve, like all curves, can be made to differ as little as we please from a straight line by dealing with a sufficiently short portion of it. And so, by limiting sufficiently the temperature rise in the calorimeter, it is possible to use a linear cooling law—that is, to take the cooling as proportional to temperature difference, which, of course, simplifies calculations somewhat. Hence a small enough interval should be used to make the cooling law linear—say, from 2° to 4°.

It is evident that this reasoning does not indicate that actual error will arise from the use of a large interval unless the observer insists on coupling with it a computation based on the linear law appropriate to a small interval. But he is not in the least obliged to do this, and there is no question that the proper expression will represent a large interval quite as well as the approximate linear law does a small one, thought not quite so simply. Hence the only considerable advantage of the short interval is a saving in labor, and while this may sometimes be worth while it is, of course, a trifling consideration whenever accuracy is of importance. Moreover, the extra labor involved in cooling computations for large intervals may, by a method to be described later, be made to average less than a minute per determination, and the error from improperly assuming a linear relation for an interval of 8° is no greater than that of the best calorimetric determinations yet made with mercury thermometers. Hence the generally accepted view that small intervals are conducive to accuracy and generally advantageous is a fallacy. (The small interval may, however, be advantageous in cases where the thermometric accuracy is more than sufficient for the object in hand.)

With a mercury thermometer the gain in accuracy from using a large interval would probably not be proportional to the increase of the interval. Just how great the gain would be in any given case is perhaps a little uncertain at present. With electrical thermometers the gain at first is practically proportional to the increase in interval and even for a 10° interval and with the best instruments the error in the thermometer is probably considerably larger than that in the calorimeter itself.

The increase of the interval meets with an obstacle in the important department of combustion calorimetry, for the water must circulate freely about the bomb and hence its amount often cannot be readily reduced. But it does not seem impossible to get around this difficulty in a satisfactory way. To take one possible method out of several: If the bomb itself were used as the stirrer, being raised and lowered by a wire, the stirring of even a small amount of water would be more effective than

that of a larger amount by the customary reciprocating stirrer, while the great drawback of the reciprocating stirrer, evaporation, could in this case be easily controlled.

The foregoing article has pointed out that the cooling correction, instead of being the largest, is easily made the least of the sources of calorimetric error, that evaporation, while much more serious, can also be controlled without difficulty, as can the heat produced by the stirrer. The way to control evaporation is to practically prevent it. With the stirrer the essential thing is to find the proper speed. Lag effects, though numerous and complicated, may easily be made to produce negligible errors. The total inaccuracy of the calorimeter, therefore, is much less than the usual error of the temperature measurement. This error can be greatly reduced, though at the cost of considerable complications, by using electrical thermometers. It can be very easily, though less effectively, reduced by increasing the temperature interval through which the calorimeter is heated. The general opinion that small intervals are generally advantageous or conducive to accuracy is a fallacy.

In a subsequent article there will be considered the practical application of these conclusions to the various details of a calorimetric determination.

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A Commercial Nitrogen Plant.

By Albert Alexander Somerville.

The air we breathe is a mixture of nitrogen and oxygen. The latter is a supporter of respiration. It is also a supporter of combustion. Nitrogen is just the opposite. It will not support combustion nor is it itself combustible under ordinary conditions. When studying the properties of a substance at elevated temperatures it is desirable to prevent that substance from combining with oxygen to form an oxide. This can most readily be done by working the substance in a vacuum or an atmosphere of nitrogen or hydrogen in order to exclude the oxygen.

Obtaining a vacuum at room temperature, and keeping it while the temperature is being raised in a furnace, are two things of different degrees of difficulty. A containing vessel through which gases will not pass at high temperatures when the pressures inside and outside are different is a rare thing. Someone has said that a vacuum is the cheapest thing you can produce, but it requires a lot of trouble to retain it.

If a metal is to be annealed it must be heated to a considerable temperature. A partial vacuum may be obtained and so only a small amount of oxygen allowed to unite with the metal to form an oxide. If it is desired to completely prevent oxidation then it is better to fill the containing vessel with some other gas so that the pressure inside and out will be equal and, therefore, reduce the tendency for the oxygen or the air to enter. Or, still better, if the inside pressure can be maintained at a value slightly higher than that of an atmosphere, thus causing a slow leakage outward, the chance for oxygen to enter is very small.

Two gases that may be used for filling the vessel are hydrogen and nitrogen.

Hydrogen is readily obtained by the decomposition of water, H_2O, by an electrical battery into hydrogen and oxygen, collecting the two gases at the two poles of the battery. Due to the low specific gravity of hydrogen a tube may be kept filled with it to the exclusion of other gases simply by inverting the tube and admitting the hydrogen at the lower open end. The two objections to its use are that hydrogen passes through the walls of a heated vessel about the easiest of any gas, and also that in some proportions with air it forms a dangerous explosive mixture.

On the other hand, nitrogen is readily obtainable from the air, of which it forms about 78 per cent by volume. It is

neither combustible under ordinary conditions of practice, such as are here considered, nor a supporter of combustion, nor does it enter readily into combustion with any other element. Also it does not so readily pass through the walls of a containing vessel.

Nitrogen is obtained by separating it from the oxygen of the air. This is done by causing the oxygen to unite with something to form an oxide and so leave nothing that will support combustion or oxidation. It may be noted that the air consists of about 99 per cent nitrogen and oxygen and the remaining 1 per cent consists of a group of gases known as the
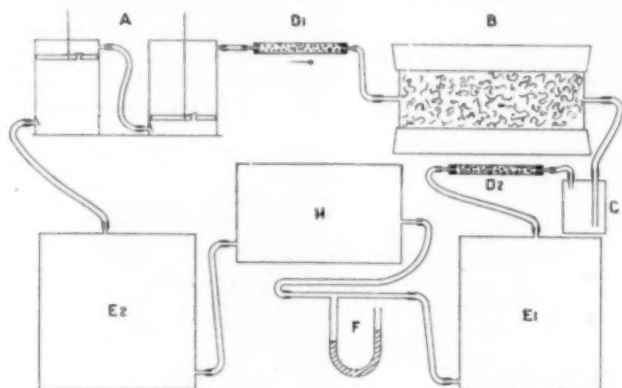

FIG. 1.—DIAGRAM OF APPARATUS FOR SEPARATING NITROGEN FROM AIR.

argon groups, none of which support combustion, and also one other, namely, carbon dioxide.

The oxygen of the air may readily be made to unite with burning phosphorus and so leave nitrogen, or air may be passed over hot copper with which the oxygen unites to form copper-oxide and thus leaves only nitrogen in which any other metal may be heated without oxidizing. The equation representing the chemical change is simply

$$Cu + O = CuO.$$
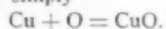
A nitrogen producing plant may be made on this principle that is quite efficient. The highest efficiency is reached by having a cyclic process and using over and over again the same product. The same is true of any kind of a system, for instance, in a refrigeration plant the same ammonia is used over and over again.

In a nitrogen plant a cyclic system may also be used consisting of a motor-driven pump, a furnace containing metallic copper, storage tanks, drying agents, pressure indicators, meters to measure rate of flow, and lastly the station at which it is desired to use the nitrogen, all connected in series so that the same gas is continually flowing through the same circuit. Such a system probably has the highest efficiency possible.

The diagram, Fig. 1, shows the general scheme. A is a pump (two cylinders in series), B a furnace containing copper, electrically heated, C a wash bottle, indicating flow of gas, D_1 and D_2 dryers, E_1 and E_2 storage tanks, F a pressure gage filled with mercury, and H the station where the nitrogen is used. The capacity of the storage tanks and conduits is nearly a fixed quantity and may be made anything desired.

The pump may be any of several motor-driven types for the movement of gas, and the rate of flow of the gas may be regulated either by varying the speed of the motor and pump or, what is better, by running these at normal speed and adjusting the partially closed stopcocks.

If there is an oil immersion used in the pump A it is well to follow this by a drying tube D_1 in order to remove any moisture from the air before it enters the furnace. This may consist simply of a large glass tube filled with calcium chloride or phosphorus pentoxide.

From this drying tube the air passes into the furnace and over the heated copper. Here the copper is oxidized and the oxygen of the air unites with it to form copper oxide. The gas that remains is principally nitrogen and will not support combustion or oxidation. The furnace is made by filling an iron pipe 3 in. in diameter and 2 ft. in length with copper shavings or droppings, capping the ends of this pipe, tapping small pipes into these caps for an inlet and outlet and providing an electrical heating coil around this receptacle.

This electrical heater may be made of wire or ribbon wrapped around the iron pipe and insulated from it either by a roll of asbestos paper or by special kinds of fireclay. The wire may be covered on the outside with asbestos or mineral wool for thermal insulation. This furnace is run at a temperature somewhat above visible red heat, 600° C. to 800° C., and if the air is not passed through it too rapidly practically all the oxygen is removed on the first trip around the circuit.

In order to determine the rate at which the gas is flowing a meter may be put in circuit, or if only a general indication is desired a wash bottle C may be used to indicate, by its bubbling, the general rate of flow and in this wash bottle something may be used, such as pyrogallic acid and potassium hydroxide, to remove any remaining traces of oxygen that may have passed through the furnace.

This wash bottle may be followed by another dryer D_2 in order to catch any liquid or vapor that may be carried over from the bottle and then connect with a storage tank E_1 and pressure gauge F. The storage tank may vary from the size of a bottle to that of a gasometer as desired. Since the pressure is generally only slightly above an atmosphere an ordinary mercury manometer may be used to indicate pressure and will indicate any large leaks.

The gas is now available for use and may be run into any station or place where it is desired. Presumably this would be a second furnace where it is desired to heat some substance in which oxidation is to be prevented. In the case of the writer he has used it in connection with the measurement of the electrical resistance of about 40 materials up to temperatures approximately 1000° C.

The nitrogen is not allowed to escape the air from this furnace, but instead is carried to another storage tank and eventu-
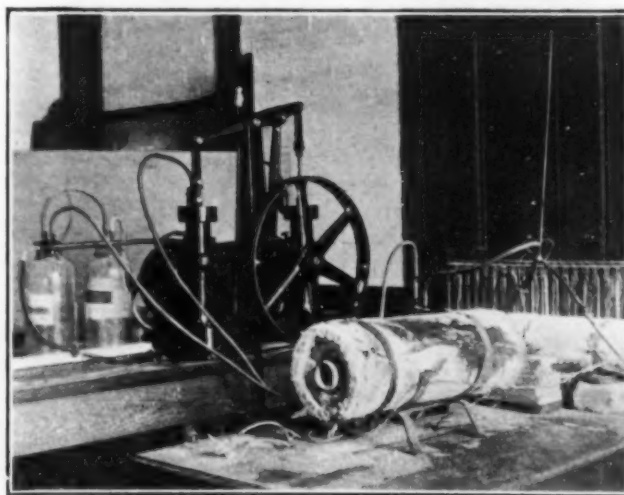
FIG. 2.—VIEW OF APPARATUS.

ally back to the pump at the starting point. Since the plant was filled with pure air at the start and about 20 per cent by volume has been removed to form copper oxide, the pressure would accordingly fall making a tendency for air to leak in from the outside in order to equalize the pressures. This may be remedied by providing an intake right at the pump so that any new air that comes into the circuit must at once pass over the heated copper and so have its oxygen removed. Finally

the circuit becomes thus practically filled with pure nitrogen.

All connections are made with pressure tubing with joints well covered with shellac.

Due to keeping the inside pressure of the circuit above one atmosphere there are usually some small leaks so that a fresh supply of air must be pumped in occasionally. In order to remove the oxygen from this copper must be changed into copper oxide and so the supply of metallic copper is finally depleted.

In order to convert the copper oxide back to metallic copper it is only necessary to disconnect the furnace from the remainder of the circuit and run illuminating gas through the furnace while it is hot. The hydrogen in the gas unites with the oxygen of the copper oxide to form water and leaves metallic copper and carbon dioxide. The equation representing it is as follows:

$$4\,CuO + CH_4 = 4\,Cu + 2\,HO_2 + CO_2.$$

This reduction is easily accomplished and the furnace is then connected into the nitrogen circuit again.

Cornell University.

Evaporators and Vacuum Pans.

By B. Viola, M.E.,
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Evaporation for the purpose of concentrating liquid plays a most important part in the sugar and the chemical industries. This process is accomplished in any of three different ways: viz., by heating the liquid by the combustion of fuel, by heating the liquid with indirect steam heat, and lastly, by indirect steam, with simultaneous reduction of atmospheric pressure upon the surface of the heated liquid, lowering the boiling point.

Any liquid exposed to the atmosphere will evaporate more or less rapidly at ordinary temperature. The normal pressure of the atmosphere at sea level is equal to that exercised by a column of mercury 29.92 in. equal to a pressure of 14.707 lb.

FIG. V.—SUGAR MANUFACTURE IN SICILY IN 1570. (FROM THE "NOVA REPERTA" COLLECTION OF JOANN STRADANUS.)

per square inch. At this pressure water boils at a temperature of 212° Fahr. If the pressure be decreased the boiling point of water or any liquid falls and it is due to this phenomenon that multiple-effect evaporating apparatus can be constructed in which 1 lb. of steam may evaporate in practice up to 5 lb. or 6 lb. of water. The evaporation increases with rising temperature; it increases until evaporation takes place not only on the surface, but all through the bulk of the liquid when the boiling point is reached. The temperature of such exposed liquid cannot increase while the liquid is boiling, as any addition of heat will but accelerate the process of evaporation.

The heat of evaporation can be determined for any liquid. The total heat of steam is $t + t_1$, where t is the amount of heat in heat units, or thermal units, which must be communi-

cated to the liquid in order to accomplish the boiling of it; t_1 is the amount of heat which evaporates the boiling liquid.

The heat required to raise the temperature of 1 lb. of water 1° Fahr. is called the British thermal unit and to convert 1 lb. of water at 212° Fahr. into steam at 212° requires 966 b.t.u. This item is called heat of evaporation. The quicker this heat is added to the boiling liquid the quicker the evaporation will take place.

Different liquids have different boiling points and are also influenced by the presence of bodies in solution.

The amount of water evaporated in a unit of time is in direct proportion to the heating surface with equal temperature.

Increase of temperature of the heating medium has the same effect as increase of heating surface—that is, the amount of water evaporated in the time unit is directly proportional to the temperature of the heating surface, its dimensions remaining
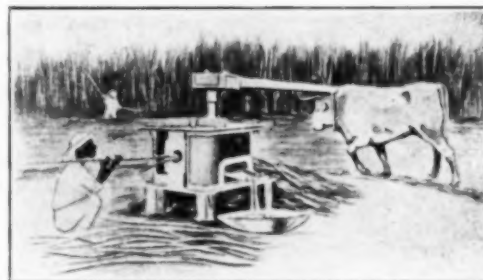
FIG. 2.—EARLY METHOD OF EVAPORATION.

equal. It is by far easier to enlarge the heating surface, hence this is always attempted in the construction of plants.

The earliest systems of evaporation were those on open fires in flat or cylindrical shaped open pans (Figs. 1 and 2). These systems can still be found for boiling sugar juices in India and in the West Indies, especially where families boil their own sugar from the juice of sugarcane. We find the first improvements in evaporators at the beginning of the nineteenth century when Dubrunfaut constructed his rocking-pan. This has a flat bottom which is heated by coal or wood fire and has a bill-shaped mouth for emptying the same. In Fig. 3 A is the pan, a the mouth, b an axle placed in the bearings, c is a moving and d a fixed roller for raising the pan. B is the oven. G the fire grates and b the fire door.

Halette's construction (Figs. 4 and 5) was a considerable improvement in evaporators. In this, A is a copper tank with a half-round front piece B with valve a in the bottom. This evaporator rests by two buttons on two iron plates b which are fastened on the wooden support c. At e is an iron leg which is turning around the axle f like a leg of a table. By loosening the bolt d the bolt plates could be turned aside and the tank could be lowered by turning the leg e around the axle. On the rod g hangs the rost-shaped heating apparatus, consisting of two prisms hh with 24 cone-shaped holes in them where the 24 copper tubes are tightened by bolts i. The steam enters through the pipes ll and from there passes in the direction of the arrows to the copper heating tubes, holes being drilled in the prisms hh between the pipes for that purpose. The use of this apparatus was not very advantageous, as the steam entering the heating pipes condensed too quickly and the pipes filled with water, which was difficult to drive off because of the high pressure required, which often burst the pipes.

Neither the evaporating system on open fires nor those with steam pipes, placed in the bottom of open kettles, could give satisfactory results, especially in the manufacture of sugar. First, the evaporation was too slow; a great amount of sugar was destroyed on account of the high boiling point and then the heating capacity of the fuel and steam was very poor. Therefore, some better method was necessary to increase the evaporative capacities of the kettles.

In order to consider everything connected with the building of such evaporators we can say that:

a. Besides the heating surface, the heat-conducting power of the material, of which the heating surface is composed, is very essential. According to Wiedemann and Franz, in Poggendorf's *Annalen*, the relative conductivity of silver is 1000; gold, 532; copper, 736; iron, 119, and lead, 85. Silver would, therefore, furnish the most efficient heating surface, but its high price excludes it from practical use for this purpose. We generally find copper employed for sugar, malt, tannin, etc., while lead or lead-lined copper and iron are used for the evaporation of acids. Further,

b. The thickness of the heating surface decreases the con-
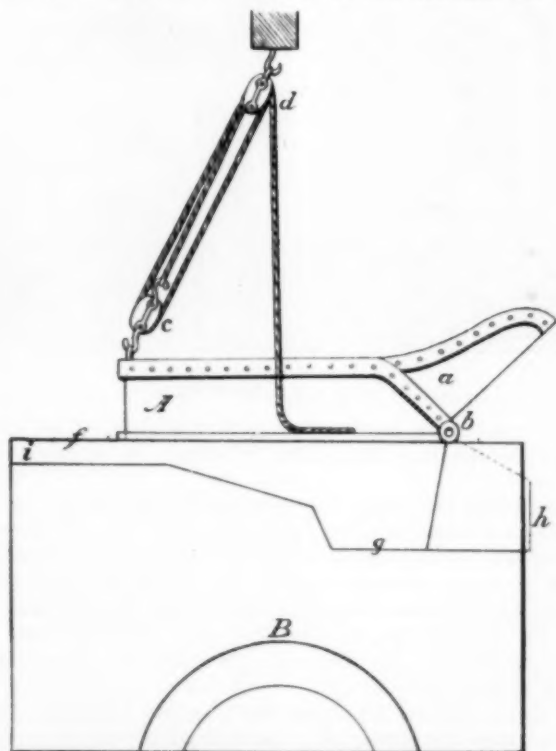
FIG. 3.—DUBRUNFAT ROCKING PAN

ductivity of heat transmission. However, the thickness employed for copper in practice is sensibly constant.

c. The transmission of heat is directly proportioned to the mean difference of temperature.

d. Thick or viscid liquids acquire heat more slowly than water or thin liquors and in such cases the coefficient of transmission is often only 0.5 or 0.2 of the coefficient of water.

e. The transference of heat is reduced to an undeterminable degree by incrustations with crystals or scales.

f. When a continuous change exists in the flow the quicker liquids or steam are dirven through the heating pipes the quicker will be the heat transmission. The shorter and smaller the diameter of the steam-heating pipe the more efficient is the heat transmission.

g. The transmission of heat is affected also by the position of the heating tubes.

With vertical tubes the condensed water is always running down on the whole surface and prevents the conductivity of heat because the steam is not in intimate touch with the heating surface; while with horizontal tubes the condensed water drops off quickly and the steam can effect its full heating capacity. Boiling depends not only on the material and area of the heating surface, but also on the pressure resting upon the surface of the liquid which is to be evaporated. The lower the pressure the less resistance the steam bubbles find in rising to the surface and so, of course, boiling can be reached by a

lower temperature. This is always the case with evaporators and vacuum pans, where the boiling of the liquids is done under a partial vacuum.

The vacuum in an evaporator is always given in inches of mercury. Thus a vacuum of 25 in. means that the excess of atmospheric pressure over the pressure in the effect would support a column of mercury 25 in. high; hence, expressed as a pressure, a vacuum of 25 in. means a pressure of 29.92 — 25 in. = 4.92 in. = 2.42 lb. per square inch.

The first apparatus for a reduced pressure was built in 1813 by Howard (Fig. 6) and is shown in section according to J. Foster. A is a boiler for boiling the liquid. It is formed of two copper pans strongly bolted together and has a double bottom where the vapor is supplied by the pipe C; D, the condensed water pipe to which is attached the air cock; E, dome in which the vapors are collected and the syrup which may be mechanically drawn in with the vapor falls again into the vessel; G, the condensing vessel to which a pipe is attached and communicates with the air pump; this pump maintains the vacuum, but is not shown in the plan.

The cold water enters the space C through the opening H and by moving the handle I, the valve K and the piston L are raised. F, the vapor pipe from the pan to the condenser. This is used for returning the liquid drawn in by the vapors into the space O, from where it is easily removed by the cock R; M is the cold-water feed pipe; N, a proof-stick for taking a proof of the syrup in the vessel without opening communication be-
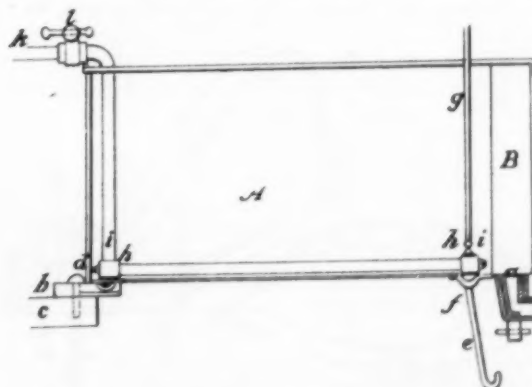
FIGS. 4 AND 5.—HALETTE EVAPORATOR

tween the interior and the air outside; Q, thermometer which indicates the temperature of the syrup.

This apparatus spread among the English colonies and on account of its advantages it was possible to get 1/6 larger results than with the open pans. The temperature difference between condensed water and syrup was 9° to 12° and the interior pressure about 50/76 and 55/76 atmosphere. For the condensing of 500 kg of vapor 10 cu. m to 11 cu. m of injection water was used and reached a temperature of 30° C.

This had several disadvantages, however; it was not possible to watch the boiling, because the vessel was closed; the dis-

charge of the syrup was very slow and needed too much power and steam. In later years the evaporating effect was improved by placing a serpentine inside and also glasses for seeing inside the vessel.

After Howard's apparatus was built Roth constructed one in France which had a jacket also and a serpentine inside (Fig. 7). The steam became condensed by a heavy water injection. The condensed water receiver had to be large enough to hold the whole quantity of one charge and was discharged after each operation. A vacuum was made before the operation started through a stream of steam (Fig. 7).

The boiling vessel A is similar to Howard's, but it contains a serpentine in which the steam circulates. D is a vessel made of iron for condensing the vapor. It is fitted with a vacuum gage m and a water gage n. E, the steam pipe communicating with the boiler; F, G, H, cocks for admitting the steam to the double bottom, the serpentine and the vessel. F_1 and G_1, cocks for the condensed water flowing from the double bottom and the serpentine; i, butter cock to prevent the mass from becoming frothy; K, syrup supply cock and pipe; L, outlet cock for the boiled syrup which is discharged into the vessel O; M, the vapor pipe to the condenser; N, metallic perforated plates, through which the cold water runs in very small streamlets and through which the vapor passes; P, injection cock connected to the pipe S which supplies the cold water; Q, cold-water supply cistern; R, cock for discharging the hot water and the air at the end of each stroke.

It is operated as follows: The vesel being empty the cocks
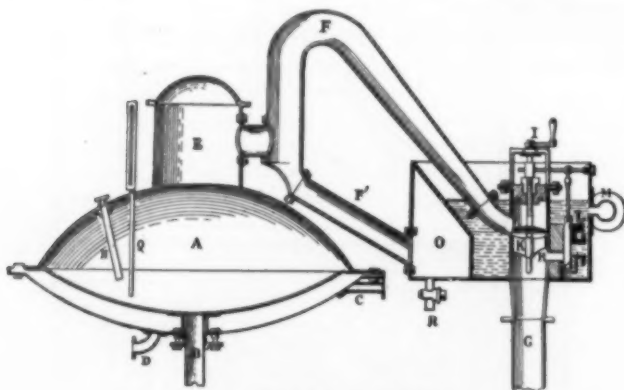
FIG. 6.—HOWARD EVAPORATOR

H and R are opened and the steam rushed into the vessel and into the condenser. A mixture of air and steam escapes by the cock R and after a few minutes, when it is suposed that all the air has been driven out, these cocks are shut and the cock K is opened to admit the syrup.

At first the liquid rises slowly with the progressive condensation of the vapor in the vessel caused by the cooling of the outer case. Afterward, when a portion of the syrup has been supplied into the vessel, it rises very quickly on account of the rapid condensation which its entrance causes.

When the syrup in the cistern is drawn out to a certain level the cock K is shut and F and G opened to admit the steam into the double bottom and the serpentine. The condensed water cocks are also opened and in a few moments the injection cock P. In a short time a proof is taken of the syrup and when it has arrived at the required point the injection cock is closed; the syrup is hot and when it reaches 80° or 90° the cock L is opened, also the air cock and the boiled syrup runs out. In order to begin a new operation, the cock R has to be opened to allow the hot water to run out and steam is again admitted to the vessel to drive out the air.

The water consumption of Howard's and Roth's apparatus should be alike and otherwise Roth's has the same disadvantages as Howard's. The vacuum could never be kept up equally, as the cooling water brought in too much air and some

gases were also always discharged from the syrup mass.

For the evaporation of larger quantities of syrup Pelletan has built an improved apparatus. In Figs. 8, 9 and 10 AA is a half-cylindrical kettle 20 ft. long and 2 ft. in diameter and is placed in the jacket BB; it is covered with the top CC and rests on legs VV; D, a condenser, 15 in. in diameter and 6 ft. high with a valve and the record plate I, for regulating the cooling water, which condenses half of the steam coming from the kettle; K, another valve for the discharge of condensed water or to connect it with a pump; H, the steam inlet valve for a
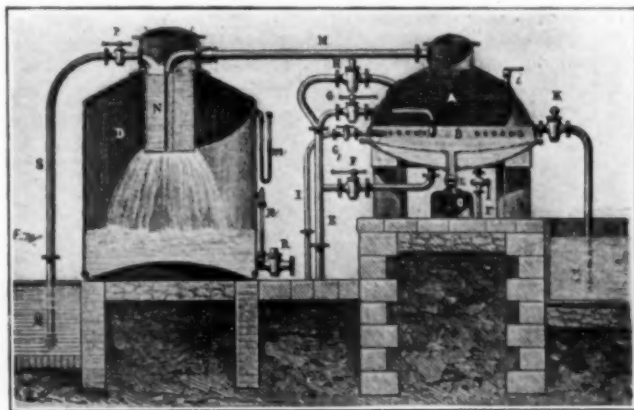
FIG. 7.—ROTH EVAPORATOR

three atmosphere steam pressure in the globe G and from there through pipes OO in the jacket for the heating of the kettle.

The steam by passing the condenser D sucks the air out and drives it into the jacket and passes through valve R when the liquor reaches the cooking point. All the steam passes through pipe PP in the condenser and the part not condensed is carried along by the steam stream into the jacket. In this way the vapors of the kettle and the live steam together make the evaporating heat. By this method Pelleton was able to keep up a vacuum of 20 in.

Valve L cuts off the evaporator from the condenser and is closed when the kettle has to be discharged. With the steam valve M the evaporated liquid is pressed through pipe S, which
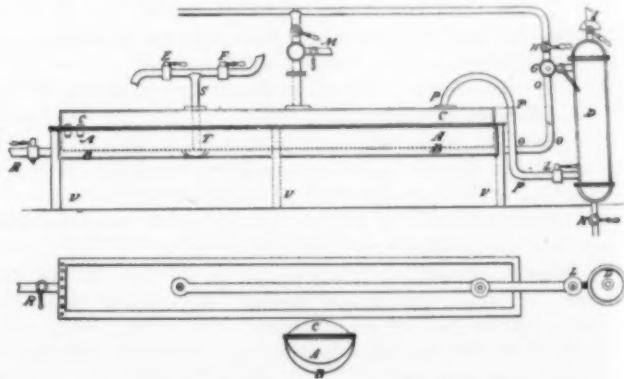
FIGS. 8, 9, 10.—PELLETON EVAPORATOR

reaches down to the bottom. The same pipe can be used to fill the kettle. Valve E is for the charging and valve F for the discharging of the kettle. The liquor was boiled here by 65° C. and the heating steam was 100° C. The quantity of cooling water used was about five times that of the evaporated liquid. This was the first apparatus where juice steam was used for helping in the evaporation and was first practically utilized in the United States by Rillieux in his construction, as we will see later on.

Before going further I wish to mention the capacities of the heating surfaces of the different evaporators or effects. I do

not want to figure the wearysome formula in this direction, but mention briefly according to practical experience the heating effect of a vacuum apparatus per square foot and per hour of a vacuum at 25½ in.

With exhaust steam at 230° Fahr. (20 lb.) from water, 2.5—2.66 gal.

With exhaust steam at 230° Fahr. (20 lb.), thin liquids, 1.5—1.65 gal.

With exhaust steam at 230° Fahr. (20 lb.), thick liquids, 0.73—1 gal.

With high-pressure steam, 266° Fahr (40 lb.), from water, 2.8—3 gal.

With high-pressure steam, 266° Fahr. (40 lb.), thin liquids, 2—2.5 gal.

With high-pressure steam, 266° Fahr. (40 lb.), thick liquids, 1—1.3 gal.

As stated above, if the normal pressure of 14.707 lb. per square inch can be decreased, the boiling point of water or any liquid can be lowered and this is the principle on which multiple evaporating apparatus is constructed. If steam at 212° Fahr. is condensed to water at 180° Fahr. it gives a certain quantity of heat and this is the difference between the total heat of steam at 212° Fahr.

This heat can raise the temperature to evaporate water which is boiling at 180° Fahr. under a certain pressure; the steam given up at this temperature can be used again to boil more water under a lower pressure and this way can be repeated many times.

The following system of construction can be mentioned:

a. Evaporators with horizontal heating pipes.

b. Evaporators with vertical heating pipes.

c. Film evaporators.

In constructing evaporating apparatus (and especially those with horizontal and vertical heating tubes or vacuum pans with heating coils) attention should be paid to the following points:

a. The heating surface should be as large as possible, since the larger the heating surface the quicker evaporation takes place.

b. The space above the liquid should be as large as possible in order to avoid drops of juice being carried along by the steam from the boiling liquid.

c. The pipes connecting the steam room of one apparatus with the heating room of the next should be made as wide as possible in order to diminish the velocity of the flowing steam and thus afford such particles of juice as may be carried along an oportunity to settle.

d. A juice catcher should be inserted between the evaporator and the condenser for the purpose of catching the drops of juice that may be carried along by the steam and conducting them back into the evaporator. The more the velocity of the steam is diminished in this intermediate chamber the smaller will be the loss from evaporation of the liquor.

After many trials in calculating the capacity of the actual evaporation in each apparatus of a double, triple and quadruple effect, for evaporation of 90 per cent and 75 per cent of the original weight of liquid, it was shown that the total evaporation in each vessel is constant and of the same order (Hausbrand).

The quantity of water to be evaporated in the first vessel is on an average of the total evaporation:

Double effect 0.466
Triple effect 0.300
Quadruple effect 0.216

The extreme cases:

Double effect .... 0.434 — 0.484
Triple effect .... 0.2777 — 0.3152
Multiple effect .... 0.1926 — 0.2335

The evaporation effected by heating is in all cases the least in the first body, but the increase in the following vessels is not very great, at most 4 per cent. In the mean it may be assumed that this evaporation in the separate vessels is in the

Double effect .... 1 ÷ 1.045
Triple effect .... 1 ÷ 1.01 ÷ 1.04
Quadruple effect .... 1 ÷ 1.005 ÷ 1.012 ÷ 1.02

The total quantity evaporated in the last vessel is

Double effect 0.534
Triple effect 0.3703
Quadruple effect 0.284

of the total evaporation of the apparatus.

In the mean the evaporative capacity in each vessel is in

Double effect .... 1 ÷ 1.045
Triple effect .... 1 ÷ 1.0075 ÷ 1.138
Quadruple effect ...... 1 ÷ 1.0055 ÷ 1.109 ÷ 1.196

According to the observations made by Classen in sugar factories and similar establishments the following ratios of transmission coefficients were calculated:

Double effect .... 1 ÷ 0.66
Triple effect .... 1 ÷ 0.70 ÷ 0.33
Quadruple effect ...... 1 ÷ 0.91 ÷ 0.75 ÷ 0.55

Should these figures be reliable and the same temperature difference taken in all the vessels the heating surfaces will be in the ratio:

$$\text{In the double effect} \ldots 1 : \frac{1.045}{0.66} = 1 : 1.58$$

$$\text{In the triple effect} \ldots 1 : \frac{1.0075}{0.70} : \frac{1.138}{0.33} = 1 : 1.44 : 3.414$$

$$\text{In the quadruple effect} \ldots 1 : \frac{1.0055}{0.91} : \frac{1.109}{0.75} : \frac{1.196}{0.55} = 1 : 1.105 : 1.48 : 2.175$$

(*To be continued.*)

Notes on the Chemistry and Metallurgy of Vanadium.--II.

By WARREN F. BLEECKER.

Methods of Analysis.

Regardless of the fact that the analysis of vanadium ore and products may be, and in most instances is, a simple procedure, chemists do not agree as to what methods give the best results. For this reason there have been proposed a comparatively large number of analytical schemes, each of which perhaps may give concordant results if used with the care and skill presupposed by the author, but which, when used by analysts who have devoted but little time to the study of vanadium compounds, are absolutely useless so far as correct results are concerned.

Vanadium may be determined either gravimetrically or volumetrically, either directly or indirectly, and it may be reported as the pentoxide or as the metal itself. At present there is a confusion due to chemists reporting vanadium in certain compounds, especially in ores, as the pentoxide, and in other cases, especially ferrovanadium, as the metal. Because ferrovanadium is at present the most important vanadium compound and because the vanadium is in this case metallic, I prefer to follow those who invariably report vanadium as metallic and not as the pentoxide.

In general, the analyst will meet with the following vanadium ores and products for analysis: Vanadiferous sandstone, roscoelite, vanadinite, patronite and carnotite; vanadate of iron, ferrovanadium, vanadic acid. In the mill there will also be the various solutions and intermediate products which are peculiar to the methods of treatment.

It is important to remember that the various ores and vanadium products met with may require diverse procedure in order to obtain satisfactory results in a reasonable time. For example, it is very necessary to know the exact grade of a carload of vanadium ore within close limits; a tenth of 1 per cent may mean 10 per cent of the entire metallic content, a variation which (in the assay) multiplied by five in the assay of zinc ore, for example, is allowable, but which in low-grade vanadium ores should in all cases be the maximum. As a mat-

TABULATED STATEMENT OF METHODS OF VANADIUM ANALYSIS.

DECOMPOSE WITH ALKALI

Na2O2, NaCO3, NaCO2 Fusion Mixture

Digest with water —
- Residue contains all Fe.
  - Add H2O2, filter
- Filtrate contains V and U
  - Methods of determining V and U together unsatisfactory.
    - Boil out H2O2, acidify with HNO3, add NH4OH
      - Residue contains ammonium uranate. Acidify with H2SO4, reduce with Zn
        - Conc. HCl, Conc. HBr, Conc. HI
        - H2SO4; evaporate to fumes, dilute and reduce with — Titrate with KMnO4
      - Filtrate contains ammonium vanadate. Acidify with — Titrate with KMnO4

Digest with dilute acid; do not filter —
- Residue contains all Fe & U
  - Boil and filter
    - Conc. HCl, Conc. HBr, Conc. HI
    - H2SO4; reduce with — SO2, H2S, then SO2, Zn, Al. etc. CuSO4 and electrolyze — Titrate with KMnO4
    - HNO3 — Add NaCO3, NaCH3CO2, Pb(CH3CO2)2, filter Pb(VO3)2
      - Weigh as Pb(VO3)2 — Filter PbSO4, treat filtrate
      - Dissolve — H2SO4, HNO3, expel with H2SO4
- Filtrate contains all V acidify with — HNO3 — Add NaCO3, NaCH3CO2, Pb(CH3CO2)2 and filter Pb(VO3)2
  - Add NaCO3 or (NH4)2CO3, then HgNO3, filter, ignite and weigh as V2O5
  - Weigh as Pb(VO3)2 — Filter PbSO4, treat filtrate — Titrate with KMnO4
  - Evaporate, weigh residue as V2O5
  - Reduce by SO2, H2S, then SO2, Zn, Al. etc. Add CuSO4, and electrolyze

If U is present dissolve in HNO3 and repeat; add filtrates to assay for U.

NaCH3CO2, Pb(CH3CO2)2, filter Pb(VO3)2 — Weigh as Pb(VO3)2 — Dissolve
NaCO3 or (NH4)2CO3, then HgNO3, filter, ignite and weigh as V2O5
- Evaporate, weigh residue as V2O5
- Reduce by SO2, H2S, then SO2, Zn, Al. etc. Add CuSO4, and electrolyze — Titrate with KMnO4

Filter PbSO4, treat filtrate — Titrate with KMnO4

DECOMPOSE WITH ACID

HNO3; add — NaOH (x), NaCO3 (y), NH4OH (x), (NH4)2CO3(y)
- Dissolve residue in H2SO3, and repeat
  - Residue contains all Fe; all U if (x)
    - Conc. HCl, Conc. HBr, Conc. HI
    - H2SO4; evaporate to fumes, dilute and reduce with — Expel with H2SO4, titrate with KMnO4
  - Filtrate contains all V; all U if (y) Acidify with — Add HNO3 and
    - Expel with H2SO4, titrate with KMnO4 — Titrate with KMnO4

H2SO4; add — NaOH, NaCO3, NH4OH, (NH4)2CO3 — H2SO4; add KMnO4
- Dissolve residue in H2SO3, and repeat, then reduce. Add FeSO4, Titrate with KMnO4
  - SO2, H2S, then SO2, Zn, Al. etc. add CuSO4 and electrolyze — Add NaCH3CO2, Pb(CH3CO2)2, filter Pb(VO3)2
    - Weigh as Pb(VO3)2 — Dissolve — H2SO4, HNO3, expel with H2SO4 — Filter PbSO4, treat filtrate
    - Add NaCO3 or (NH4)2CO3, then HgNO3, filter, ignite and weigh as V2O5
    - Evaporate, weigh residue as V2O5
    - Reduce by SO2, H2S, then SO2, Zn, Al. etc. Add CuSO4, and electrolyze — Titrate with KMnO4

HCl; add — H2SO4, HNO3 — Evaporate to fumes, dilute and add KMnO4 — Add FeSO4, titrate with KMnO4
- Titrate with KMnO4, Expel HCl and proceed as under HNO3 — Titrate with FeSO4

HF; add — H2SO4, HNO3 — Expel HF or HCl and proceed as under H2SO4 or HNO3

Aqua Regia; add — H2SO4, HNO3

ter of fact I have always repeated assays which do not check within four-one-hundredths. On the other hand, in the assay of mill solutions and products a variation of 1 per cent or more may be allowable, excepting, of course, the final assay of marketable products.

A method of analysis should, therefore, be chosen which will give sufficiently accurate results in the quickest possible time.

For convenience of illustration and reference I have designed the accompanying analytical scheme by means of which the various methods may be compared. While there is no pretension of completeness, the outline is sufficiently comprehensive to embrace most of the important analytical methods which have been proposed.

Decomposition and Solution.

The first operation in the analysis of vanadium compounds is obviously solution, but the difficulties attendant upon the quantitative solution of vanadium are not always understood or appreciated, possibly for the reason that a portion of the vanadium content goes into solution with extreme ease and rapidity.

As will be seen by referring to the table, the following reagents are used in dissolving vanadium, no one reagent being suitable for all of the vanadium compounds met with: Sodium peroxide, caustic alkali, sodium and potassium carbonates, mineral acids and water. In some cases heat is not necessary, but in all cases heat aids solution of vanadium salts, and when the fixed alkalis are used in the dry way, fusion must be made.

It is desirable at all times to have the substance to be analyzed in a fine state of subdivision, at least through an ordinary 100-mesh screen, and in the case of ores, particularly roscoelite, to pass all of the material through a 200-mesh screen. In this way the protective surface of insoluble compounds, while relatively much greater, is thin enough to allow the dissolving reagent to act upon practically all of the vanadium in the largest of the particles present in the mass. If fusion methods are used fine grinding is not so important, yet a much lower heat is required to effect decomposition if the material is in a finely divided condition than if merely ground to 20-mesh, as is directed by the authors of some methods. And, in any event, there is nothing to be lost in fine grinding, excepting, perhaps, a little time, which is amply regained in subsequent operations and which is again paid for by confidence in the completeness of the decomposition.

There is no ore or compound of vanadium that is not attacked by sodium peroxide in a state of fusion. Decomposition by means of this powerful reagent is, therefore, the most important, and if subsequent operations of the analysis will permit a general rule might be laid down that it should always be chosen when there is any doubt regarding the reagent to be used.

Fusion with sodium peroxide may be made in either iron or nickel, the iron being attacked more vigorously, but being at the same time much cheaper. Fused silica has been tried, but with little success. In the first place it is attacked to a considerable extent by the sodium peroxide, and, in the second place, the crucibles crack after a few melts. I tried four fused-silica crucibles and obtained the same results with each. Fused silica would be desirable for the reason that the large mass of iron or nickel hydroxide would be avoided, and filtering would be easier, and the analyst could be more certain that all of the vanadium was in the filtrate upon the removal of the residue insoluble in the sodium peroxide.

Having fused the vanadium compound with sodium peroxide (melting is not necessary, and should be avoided) it is a troublesome operation to filter the alkaline solutions after the requisite amount of water has been added to dissolve the melt and dilute the alkali so that it will not attack the filter. Analysts have sought to avoid this operation by devising methods which would permit of the determination of the vanadium in the presence of iron and other substances which may be present in the original compound.

Decomposition by Sodium Peroxide.

To effect decomposition by means of sodium peroxide I prefer to mix 200 mg to 2 gm of the finely divided substance with 1 gm to 5 gm of sodium peroxide in a small nickel crucible and heat gently until the mass darkens, as may be seen after heating for a few moments. As soon as the heating is finished the mass is removed by carefully dropping the hot crucible in a small beaker of cold water, the operation being conducted as follows: About 40 cc of cold water are poured into a beaker with a capacity of at least 200 cc. The hot crucible is grasped by the edge with a pair of curved crucible tongs and dipped into the water with a swirling motion in order to avoid breaking the beaker. None of the water should be allowed to splash into the crucible at this point because of the possible loss of vanadium by spattering. The crucible is finally set in the water which will have cooled it and distributed the energy somewhat. A cover glass is placed over the beaker, and by a gentle rotary motion small portions of the water are thrown into the crucible, causing a more or less violent action and tending to throw a portion of the melt out of the crucible and the beaker as well. If care is used nothing will be lost, and finally the beaker and contents may be set on the hot plate to complete the disintegration and solution. The crucible may then be removed with a glass stirring rod, thoroughly scrubbed with a policeman and rinsed with a stream from a wash bottle. The entire operation from the time weighing was begun ought not require more than 10 or 12 minutes. The residue will settle readily in the hot alkaline solution, which may be decanted through a filter. The first wash water also may be decanted. One or two washings on the filter will remove all of the vanadium from the residue and unless washing has been carried too far, there will be no iron in the filtrate.

In case it is desired to dissolve the iron with acid it is, of course, not necessary to filter at this point, and the acid may be added directly to the solution after the crucible has been removed. In case uranium is present a considerable quantity of hydrogen peroxide is added to the alkaline solution, when the uranium will go into solution along with the vanadium. If the hydrogen peroxide is expelled by boiling before the filtration is made the uranium will be found for the most part in the residue, because the uranate of sodium is only soluble in an alkaline solution containing an excess of hydrogen peroxide.

Assuming the absence of uranium and the removal of the iron at the first opportunity, the vanadium in the filtrate may be determined in a number of ways, as will be seen by referring to the table. The very shortest method from this point on, and one which will give perfectly reliable results, is one which I devised by the use of electrolysis.

Reduction by Electrolysis.

The filtrate, free from iron and containing no uranium, is made acid with sulphuric acid and about 10 cu. cm added in excess. It is then heated to boiling and about 50 mg of pure copper sulphate added. The hot solution is electrolyzed for 10 minutes, the same procedure and current conditions being observed as in the electrolytic determination of copper with a rotating anode. The copper will not be completely deposited in 10 minutes, but it will not interfere in the subsequent titration with potassium permanganate. The solution is immediately titrated without further heating. After titration the solution is again heated to boiling and again reduced as before. The copper deposited on the cathode may be dissolved almost instantly in the solution by momentarily reversing the current, thus avoiding the use of a greater quantity than originally added. The analysis may be thus repeated as many as five times, and the results should agree as closely as the analyst can read the burette. A complete analysis may be made by this method in less than an hour, titrating three times.

Other Methods of Reduction.

The reduction of vanadium assays by means of hydrogen sulphide involves the removal of the precipitated sulphur which always separates out of the acidulated solution, and it is only necessary when some interfering second group element is present. The result must be checked by a second reduction with sulphur dioxide and it is seldom that the results agree within the allowable limit of error.

The reduction of vanadium assays by means of sulphur dioxide is the one generally employed. The results are invariably high and due correction must be made by a blank test using pure water acidulated with sulphuric acid. Moreover, the presence of sodium and ammonium salts, as well as silicates, interferes seriously with accurate work when this reducing agent is used. It is customary, therefore, to remove these substances before reduction by the lead acetate method of Roscoe, the steps of which are shown in the table. The objections to this method are the length of time involved in making the separation (especially if much silica is present) and the constant opportunity for error due to the several different manipulations involved.

Numerous methods of reduction with metallic zinc, magnesium, aluminium and the like have been repeatedly tried and without success. It is stated that one metal will carry the reduction completely to one stage of oxidation and another metal will carry it completely to another, thus providing a method of assay not involving the removal of iron, but I have never been able to do these things, and have no hesitancy in saying that so far as useful results are concerned they are impossible under the stated conditions.

A method of analysis which does not involve the separation of iron has been proposed, and is being used, I understand, by some large producers and buyers of vanadium ores and products. I have never had the opportunity of making a personal investigation of the method, but it has been highly recommended from reliable sources.

Decomposition may be made by either acids or alkalis, preferably with sodium peroxide. The crucible is removed as described above, and dilute sulphuric acid is added in slight excess. The hydrogen peroxide is destroyed by the addition of potassium permanganate, and the vanadium is reduced by the addition of ferrous sulphate, the final titration being made with potassium permanganate. The ferrous sulphate solution need not be standard and the amount added is not measured. The theory of the operation is that, beginning with a solution containing both iron and vanadium in their highest state of oxidation, the addition of ferrous sulphate will reduce only the vanadium, and the amount necessary to complete this reduction will, of course, be oxidized, and any excess of this quantity will be observed by a spot plate test, using potassium ferricyanide as an indicator.

The method in detail as follows was outlined to me by Mr Arnold J. Guerber, who, however, does not claim the invention.

Fuse 0.2 gm to 5 gm of the product or ore, depending upon the grade, with 2 gm to 10 gm of sodium peroxide in an iron crucible. Leach melt with water, heat, and add 20 cc sulphuric acid (1-1). Boil the solution until the hydrogen peroxide is decomposed, as shown by the disappearance of the red or pink color. Add sufficient permanganate to give a permanent pink. Now add ferrous sulphate until a spot test with potassium ferricyanide gives a distinct blue. Run back carefully with permanganate until this color just disappears in spot after 15 seconds. Then read KMnO$_4$ burette and titrate to a distinct pink color, which should endure at least 30 seconds. Solutions:

Potassium ferricyanide—dissolve 50 mgm in 10 cc water.

Ferrous sulphate—3 gm FeSO$_4$ and 10 cc H$_2$SO$_4$ in 150 cc water.

Potassium permanganate—1 cc = about 0.005 gm Fe.

Fe factor × 1.6316 = V$_2$O$_5$; or Fe factor × 0.916 = V.

Theoretically the method is open to objection because the action of iron and vanadium in the presence of a reducing agent is reversible, as may be easily proved experimentally.[1] If a solution of hypovanadic acid or its salts be added to a solution containing ferric iron, the presence of ferrous iron is immediately observable. According to this we should expect low results, owing to the mass action of the reduced vanadium upon the ferric iron, giving a test for ferrous iron before the vanadium is all reduced. That correct results are obtained may be due to the fact that a stated length of time is given for the spot-plate reaction to take place, or to some other modifying condition which compensates for the reduction of the iron which must take place.

A method has been proposed by means of which the titration of vanadium in the presence of iron is made directly with a standard solution of ferrous sulphate. Since the method seemed attractive a great many experiments were performed to try it out. The results were very unsatisfactory, because in almost every instance a spot-plate test for ferrous sulphate would show its presence long before reduction was complete, and there appeared to be no constant error that could be taken into account.

Separation of Vanadium and Iron.

It is usually a very difficult matter to make a complete separation of iron and vanadium. This is true on account of other elements being present, for the separation of iron and vanadium in a high-grade vanadate of iron is very easy. It is in the low iron products that the separation becomes a serious matter. The elements which interfere with the separation and which are almost invariably present are alumina and lime. In the high-grade vanadium compounds these elements are not usually present in such quantities as to affect the separation of the iron unless the product is a vanadate of aluminium or a vanadate of lime. But in the case of ores, such as vanadiferous sandstone or roscoelite, the alumina and lime are high, while the iron is low, and it is here that the difficulty arises.

If to a concentrated solution of aluminium vanadate in a mineral acid either ammonia or ammonium carbonate be added there will result a flocculent yellowish precipitate which consists of aluminium hydroxide contaminated with aluminium vanadate. If the solution be largely diluted before the ammonium salt is added the precipitate will usually be white and consist only of the aluminium hydroxide. If the above experiment be repeated, using the vanadate of calcium instead of the vanadate of aluminium, the results will be very similar. It must be remembered, therefore, that when either lime or alumina are present in the sample taken for assay the solutions must be dilute in order to effect the separation of the vanadium from these elements; indeed, all of the vanadium may be carried down under certain conditions of concentration. It is equally true that iron may also carry vanadium down as vanadate of iron, but if the solution is sufficiently dilute and there is an excess of the vanadium solvent present it is not likely that iron alone will cause the trouble that either of the above-mentioned elements will.

Care must be taken, however, to oxidize both the iron and the vanadium before attempting a precipitation. The iron must be oxidized because ferrous hydroxide, as is well known, is colloidal. The vanadium must be oxidized because salts of hypovanadic acid are partially insoluble in dilute alkalies, especially ammonia.

It will be clear, then, why sodium peroxide is the ideal reagent for separating vanadium from iron, the solutions being made dilute before attempting to filter. All of the elements are oxidized, and the aluminium goes into solution with the vanadium, as well as most of the lime. If desired, the aluminium, lime and silica may be separated later by any one of a number of methods.

If an acid decomposition has been made and it is desired to make the iron separation, we are usually advised to add am-

monia and ammonium carbonate. We are also further warned, and very properly, that the separation is not complete with one precipitation, but that several subsequent precipitations may be necessary in order to remove all of the iron from the vanadium and all of the vanadium from the iron. I have found that the separation appeared in many assays to be impossible, and after a half dozen times of redissolving and reprecipitating there was apparently as much vanadium in the iron residue as after the first precipitation. In such cases if the third precipitation be made with sodium carbonate, the separation will be complete. I have assumed that this phenomenon is due to the fact that the aluminium which was retaining the vanadium each time is dissolved, or, rather, not precipitated, and cannot further interfere with the complete removal of the vanadium from the iron.

The vanadium in mill solutions which do not contain iron may be readily determined as follows: 25 cc of the solution is diluted with about 150 cc water and an excess of sulphuric acid is added; 50 mg of copper sulphate is added to the solution and the assay heated to boiling and electrolyzed as described above. The relatively large quantities of sodium, lime and other salts present do not interfere with the determination.

Vanadic acid may be decomposed readily by digesting the assay in a hot solution of either sodium or potassium hydroxide to which a little hydrogen peroxide has been added, and the subsequent determination made by any method desired. If one attempts to decompose vanadic acid which has been fused, with an acid, the operation will be found to be tedious and unsatisfactory, whereas the alkali will effect a complete solution almost immediately if there is an oxidizing agent present.

Inaccuracies of Some Methods.

There are a number of methods which are not included in the table, because of their inaccuracy or general unfitness for commercial work. Of these I shall mention but one or two. One of the first methods for the determination of vanadium consisted in getting the vanadium into alkaline solution and precipitating it as ammonium metavanadate by means of ammonium chloride. This method has caused much discussion, and Gooch and Gilbert[2] did some very painstaking work to determine its accuracy. They determined that the precipitation is complete if the solution is so saturated that the ammonium chloride separates out, and the solution so saturated is allowed to stand for 24 hours. I should like to point out that the vanadium salts used in these experiments were pure, and that sodium salts, silica and the like were entirely absent, conditions which seem to make the experiment of academic interest merely and of small value to the analytical chemist.

Several investigators have tried to determine vanadium as the sulphide, either by precipitation from alkaline solution with hydrogen sulphide or by the addition of sodium sulphide and acidifying the solution with a mineral acid. The precipitate formed in these instances is an impossible colloid and represents only a fraction of the vanadium in the original solution.

Brearly and Ibbotson[3] suggest, beside the ammonium metavanadate method, the determination of vanadium by precipitating a dibarium vanadate from an alkaline solution, which vanadate may be ignited and weighed. The insurmountable obstacle here seems to be as in the case of lead vanadate, Prescott and Johnson[4], that the compound is not of constant composition.

The same authors also state that it has been proposed "to weigh the carbon dioxide evolved on reducing vanadium pentoxide with oxalic acid."

Koppel and Goldmann[5] have shown that the action of oxalic acid upon vanadic salts gives hypovanadic salts and vanadyl oxalate. It does not seem clear that these products are formed in any definite ratio, and it is a fact that the reduction of numerous samples of a standard vanadyl sulphate solution with oxalic acid gave results which were so widely different that they were of no value, and no result was obtained which agreed with the true value as determined by standard methods.

The mercurous nitrate method of Rose should be mentioned as a standard method involving serious difficulties. As given by Treadwell[6] the silica would be weighed as vanadium pentoxide. The removal of the silica is a tedious procedure, but unless it is removed there is a very strong probability that a portion of it at least will be precipitated with the vanadium. Moreover, the vaporization of mercury is not an easy matter, as is well known, and unless the quantity of vanadium pentoxide in the assay is very small, the result is apt to be high on account of the traces of mercury remaining in spite of the heat applied.

The modification of Roscoe's lead-vanadate method,[7] in which the final acid solution containing the vanadium is evaporated and the residue weighed as vanadium pentoxide, is not altogether satisfactory. The lead cannot be entirely removed with hydrochloric acid, and the evaporation of sulphuric acid is unpleasant as well as difficult. The safest procedure is to precipitate the lead with hydrogen sulphide from a hydrochloric acid solution, and the opportunities for error here are too well known to require discussion.

Colorimetric methods have been advocated, but do not seem to have met with an enthusiastic reception.

The reduction of vanadium by means of the halogens has been very carefully worked out, and the investigators[8] seem to be unanimously of the opinion that the results are accurate. The care with which the work must be performed and the length of time required seem to be obstacles which will forever prevent these methods coming into general use.

(To be continued.)

The New Ozone Purification Plant of the Water Works of St. Petersburg.

By DR. G. ERLWEIN.

The City of St. Petersburg, in Russia, has built a large ozone purification plant for their water-works to sterilize the drinking water. The special object is to combat the epidemics of cholera morbus which have occurred every year now for some time, and the typhoid epidemics which have already become chronic. This ozone purification plant has started operation at the beginning of this year.

For the water supply of the City of St. Petersburg three large water-works were formerly used, of which only the largest one, however, used sand filtration, while the other two pumped the river water from the Neva River without purification into the water supply pipes of the city.

The new ozone purification plant is used in connection with one of the two water-works formerly operating without filtration and supplies water to a district consuming daily 50,000 cu. m (13,200,000 gal.) of water. The purification of the water consists in rapid filtration with subsequent ozonization. In view of the large amount of suspended material in the water, especially when ice is in the river, the rapid filtration is combined with clarifying by means of aluminium sulphate. The Penkowaja ozone purification plant consists, therefore, of two main parts, first the filtration plant and second the ozone plant proper.

As will be seen from the diagram, Fig. I, the river water is pumped directly from the Neva River and the suspended matter is first removed. For this purpose, before the water enters the sedimentation basins, aluminium sulphate solution is added to

[1] *Western Chemist and Metallurgist*, Vol. 5, No. 2, p. 54.
[2] *Zeit. f. Anorg. Chem.*, 1902, p. 174.
[3] "Analysis of Steel Works Materials," Ed. 1902, p. 87.
[4] Prescott & Johnson, "Qualitative Chemical Analysis," Ed. 1908, p. 136.
[5] *Zeit. f. Anorg. Chem.*, 1903, p. 281.

[6] Treadwell & Hall, "Quantitative Analysis," Vol. 2, p. 231.
[7] Treadwell & Hall, "Quantitative Analysis," Vol. 2, p. 233.
[8] *Zeit. f. Anorg. Chem.*, 1902, pp. 66, 71, 456; 1904, p. 246.

the water in proper dilution according to the well-known American practice.

The sedimentation basins are shown on the left of Fig. 2. Their number is eight, and by means of pipe lines they are connected with the filter tanks shown on the right hand of Fig. 2

The rapid filter tanks, of which there are 38, are of the Howatson systems, which is very similar to the well-known American Jewell filter. Their construction is well known, but it may be mentioned that Howatson fills his filters not with the
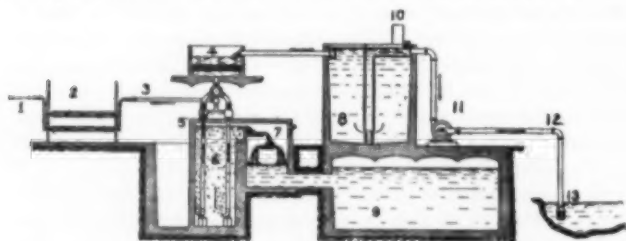

FIG. 1.—DIAGRAM OF OZONE WATER STERILIZATION PLANT AT ST. PETERSBURG.

1, air pump; 2, ozonizer; 3, ozone pipe; 4, rapid filter; 5, injectors; 6, sterilization tower; 7, cataracts; 8, decantation vessel; 9, storage of purified water; 10, aluminum sulphate addition; 11, pump; 12, raw river water; 13, Neva River.

usual crushed filter sand, but with "so-called prepared silex (flint)."

The filtration speed is 4.5 m (14.8 ft.) per hour.

The purification of the filters is carried out in the well-known manner by passing filtered water back through the filter and simultaneously stirring the silex filling by means of agitating devices, which are clearly shown in Fig. 3.

The filtered water is passed through a pipe line directly to the ozone-sterilization towers. A small part of the filtered water, however, is conducted into a storage tank, which contains the
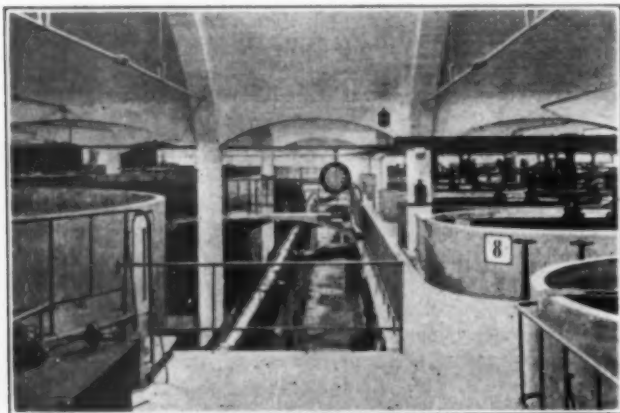

FIG. 2—SEDIMENTATION AND FILTRATION PLANT.

water used in washing the filters. While in slow filtration sand filters are expected to remove the bacteria, the rapid filters in this case are not intended to do this. Their principal object is to remove the suspended and coloring matter from the water.

As the next step after the filtration just described comes the ozone treatment proper. In the ozone plant two parts must again be distinguished, namely, the ozonizers and the sterilization towers. Fig. 4 shows the ozone plant, consisting of 128 ozonizers, and Fig. 5 shows the five sterilization towers, one of which is used as reserve. The ozonizers are of the well-known Siemens & Halske tube type (see, for instance, our Vol. I, page 179). These ozonizers change the oxygen of the air into ozone by means of high-tension discharges.

On account of the method of operation of the injector sterilization towers a relatively high value has been chosen for the concentration of ozone, namely, 2.5 grams of ozone per

cubic meter of ozonized air. Before entering the ozonizers the air is properly dried by means of a refrigerating machine; this drying increases the yield of the ozone in the ozonizers.

The movement of the air through the ozonizers and pipes is accomplished by means of Otto injectors, which operate with a water pressure of 4 m (14 ft.) and suck the ozonized air from the ozonizers and drive it mixed with the water into the sterilization towers. The absorption of the ozone and the sterilization of the water occurs partly in the injectors at the top of the sterilization towers and partly in the towers in which the ozonized air rises from the bottom in a very finely subdivided state and, therefore, in very intimate contact with the water.

From the injector-sterilization towers the water is passed in cascades (to remove the air) into a pipe line which brings the sterilized water to the storage tank for pure water. From there the water is pumped by high-pressure pumps into the supply pipe lines.

For the operation of the whole plant a special electric station has been erected, containing boilers, steam engines and three-phase generators. By means of three high-frequency converters the three-phase currents produced in the generators are brought to a frequency of 500 periods. This is necessary because the ozonizers require a high-frequency current. By
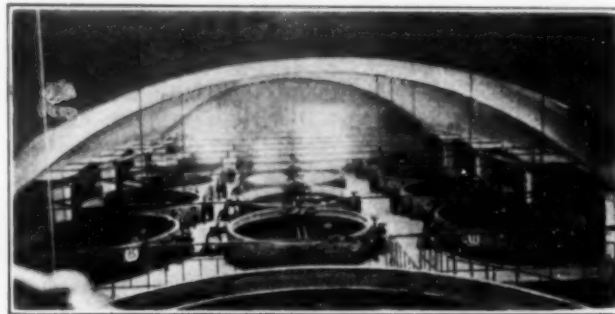

FIG. 3.—RAPID FILTRATION PLANT, SHOWING STIRRING DEVICES.

means of transformers the voltage of the currents is raised to 7000 volts, which is the operating voltage of the ozonizers.

The power plant contains two steam engines, each of 150 hp. direct-connected with three-phase generators. A third machine is used as reserve. In the other parts of the plant a reserve of about 30 per cent is also provided.

With reference to the machine capacity of 2×150 hp, it is to be taken into consideration that the electric current is used not only for the ozonizing plant, but for driving the numerous motors of the filtration plant which are employed for driving the stirring devices, the filter washing pumps, etc.

The large basins, sedimentation tanks and filtration tanks are built of reinforced concrete.

As to the cost of operation experience has shown so far that if the cost of aluminium sulphate and rapid filtration is included, the cost is about 0.9 kopeken to 1 kopeken per 100 wedro (about 0.4 cent to 0.45 cent per cubic meter of water). For ozonization alone the cost is about one-half this amount. Under conditions as they exist in Germany it may be estimated that the cost of the ozonizing plant, not including aluminium sulphate treatment and rapid filtration, would be about 0.6 pfennig (0.15 cent) per cubic meter.

With respect to the physical and bacteriological purification effects, this combined rapid filtration and ozonizing system fulfills all expectations. The dirty river water of the Neva is changed into a clear and hygienically perfect drinking water. The number of bacilli spores in the ozonized water is very low, varying between 0 and 3 per cubic centimeter. Coli bacteria or pathogenous spores of cholera morbus and typhoid are not found in the sterilized water.

It may be emphasized that the city officials of St. Petersburg

are especially interested in the bacteriological effect of the ozonizing process and have appointed a committee consisting of well-known Russian bacteriologists and sanitary water engineers which supervise the operation of the works and continually control the results obtained.

Before the new commercial ozonizing plant was opened this committee of experts had made very careful experiments on the ozone treatment of water from the Neva River on a somewhat large scale in an experimental plant treating 100 cu. m
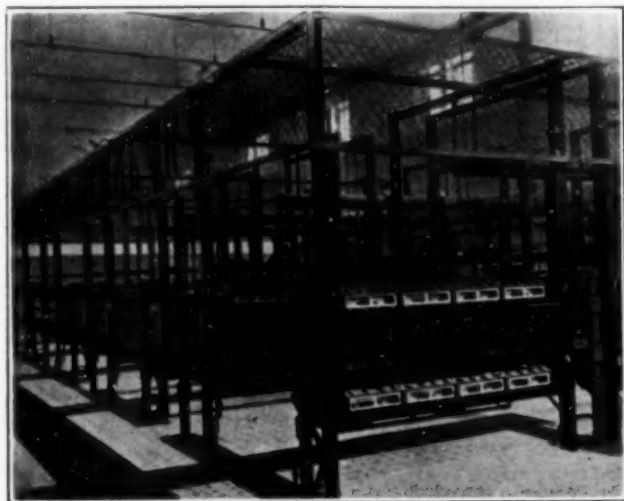

FIG. 4.—OZONIZER PLANT.

of water per hour and had thus thoroughly investigated the problem of the general use of ozone for the sterilization of drinking water, especially under such unfavorable conditions as exist in St. Petersburg.

The plant has been built for the city by the Russian Siemens & Halske Company, which has also undertaken the operation of the plant for the first years. The design and the construction of the works was made by the Siemens & Halke Company and
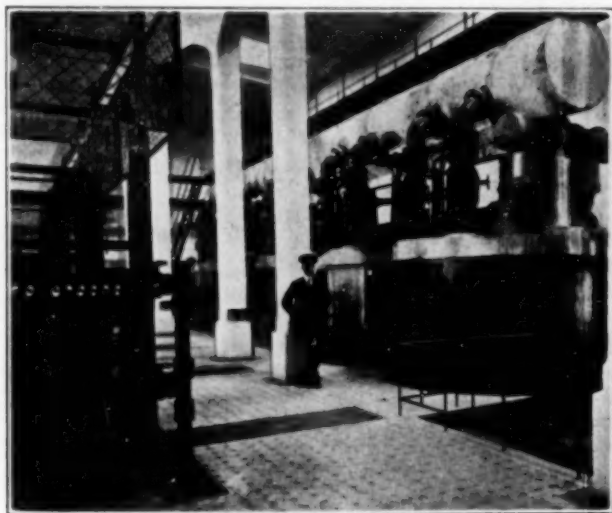

FIG. 5.—STERILIZATION TOWERS.

by the Compagnie de l'Ozone, which furnished the injector-sterilization towers of the Otto type, and by the Felten-Guilleaume-Lahmeyer Company, which furnished a part of the electrical equipment.

Two very large ozone purification plants for the treatment of water, each of a daily capacity of 45,000 cu. m (12,000,000 gal.) will be erected for the City of Paris, in France, within this year. The process of treating water by ozone is thus used now on a large scale to supply drinking water from a central plant, the different steps of this evolution being indicated by the plants erected in the cities of Paderborn, Wiesbaden, Hermannstadt, Florence, Nizza, Chatres, Villefranche, Rovigo, Chemnitz, and St. Petersburg. In view of this progress the doubts which originally existed, especially even among German engineers, concerning the technical and commercial suitability of the process may be considered to have been proven unfounded. It may be expected that in the future other large water-works with particularly unsanitary conditions will make use of this modern and hygienically important method of water purification.

Berlin, Germany.

The Annealing Process as Applied to the Manufacture of Malleable Iron.*

By W. P. Putnam.

To emphasize tht importance of exercising greater care in manufacturing malleable castings and to point out some of the sources of error that are so frequently found in foundries that leave the annealing process to the judgment of some individual with a "trained eye," the work of this paper was undertaken. There is no branch of the foundry business that needs a closer supervision than the process of annealing iron; no greater source of economy; no one department where greater skill is required, and yet it is safe to say that very few foundries
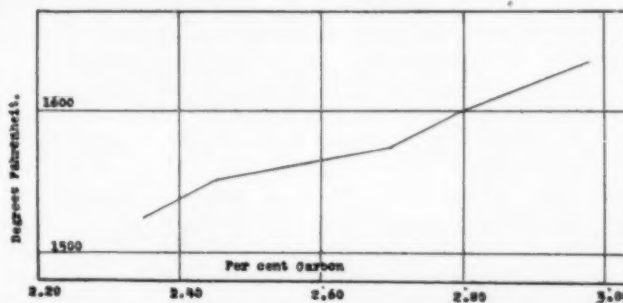
FIG. 1.—PROPER FINISHING TEMPERATURE FOR THE ANNEALING OF WHITE IRON IN RELATION TO CARBON CONTENTS.

recognize the importance of equipping their annealing ovens with proper appliances to insure a uniform product.

To call attention to the variations that can be produced in the annealing process a set of test bars was made and sent out to a number of malleable iron foundries to be annealed in accordance with their usual practice. The bars were all made from the same metal and an attempt was made to obtain a bar free from shrink or draw in the center by casting the bars with large ends. In all of the bars that were broken but very little draw was found.

The analysis of the metal poured into the bars was as follows:

	Per cent.
Silicon	0.74
Sulphur	0.041
Phosphorus	0.148
Manganese	0.24
Combined carbon	2.70

The results obtained on the annealed bars are given in Table I.

It will be noticed that in each case where too high temperatures or a long period of annealing were practiced the carbon was nearly all removed. Either practice is wasteful and produces poor malleables for some purposes.

The annealing process should be conducted to produce definite results. Metal intended for parts where machining is

*A paper presented before the Detroit Foundrymen's Association.

TABLE I.

*No.	Total Carbon.	G. C.	C. C.	E. L.†	T. S.†	Elong. in 2″.	Red. in Area.	Kind of Packing.	Time of Anneal.‡	Anneal Temp.§
1.	1.49	1.49	Trace	29823	40996	8.59%	12.13%	Slag	112 hrs.	1450
2.	1.94	1.94	"	34134	44034	10.15%	13.87%	Mill scale	144 hrs.	1700
3.	1.47	1.47	"	29276	39633	6.59%	17.63%	" "	101 hrs.	1620
4.	.86	.77	.09	31428	48489	8.59%	19.18%	Not given	Not given	Not given
5.	1.74	1.74	Trace	30960	45760	8.59%	14.88%	" "	" "	" "
6.	1.71	1.71	"	28326	40408	8.59%	15.00%	None	72 hrs.	1650
7.	1.32	1.18	.14	32224	49107	8.59%	13.23%	Not given	Not given	Not given
8.	.80	.80	Trace	33333	47336	7.60%	17.27%	Slag	208 hrs.	1620
9.	1.58	1.58	"	30833	39862	7.03%	19.51%	Mill scale	168 hrs.	Not given
10.	.40	.40	"	41792	50849	7.45%	20.92%	" "	96 hrs.	2200
11.	1.32	1.32	"	35042	45213	7.80%	12.56%	Slag	144 hrs.	1700
Hard Iron			2.70		50846					

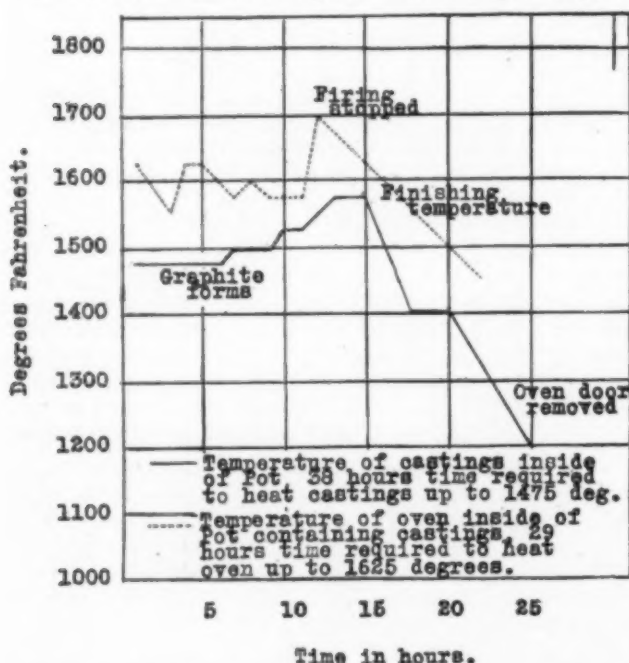*Foundries represented. †Pounds per sq. in. ‡Total hours. §Degrees F.

FIG. 2.—TEMPERATURE CURVE OF TYPICAL ANNEALING CYCLE.

necessary should be given a different treatment in the annealing process than metal that does not need to be machined.

To arrive at the proper annealing temperature the critical and proper annealing temperature was ascertained on a number of hard iron specimens ranging from 2.35 per cent to 3 per cent total carbon. These temperatures are diagramatically shown in Fig. 1. These temperatures are accurate within 10 deg. Fahr.

In Fig. 2 is shown the curve of a typical anealing cycle in an oven containing 14 tons of castings. The carbon in this lot of iron was 2.65 per cent. After the metal reaches the annealing temperature there is no further rise in the temperature of the metal until all of the carbon has changed into the graphitic condition. As soon as the change has been completed the temperature will rise in accordance with the temperature of the oven.

It has been found that to heat the castings much above the proper annealing temperature for a long period is not only unnecessary but a waste of fuel and produces poor castings for some purposes. After the carbon has all been changed the oven need not be fired for more than six hours. When the metal has gradually cooled to 1200 deg. Fahr. the cooling can be hastened as rapidly as desired without harming the quality of the castings.

Some of the reasons why hard and brittle castings are occasionally found may be summed up as follows:

1. Under annealing (which may be caused by too low temperature or by holding the castings at the proper temperature for too short a period).

2. Too rapid cooling of the castings after being annealed.

3. Heating anealed castings above the critical temperature to straighten without subsequent annealing.

That there is great need of the systematic handling of the annealing process is clearly evident from the results tabulated in Table No. 1. The variations shown there are typical of castings in general.

Detroit Testing Laboratory,
    Detroit, Mich.

Notes on Chemistry and Metallurgy in Great Britain.

(From Our London Correspondent)
The Corrosion of Brass and Copper.

At a recent meeting of the Liverpool Engineering Society Mr. G. D. BENGOUGH read a paper on this subject, in the course of which he stated that modern investigations indicated that for the continuous solution or corrosion of metals and alloys it was necessary that there should be in and around them substances which could form voltaic couples. There must be areas capable of acting respectively as anodes and as cathodes and also a fluid capable of acting as an electrolyte. When sea water was passing through a metal tube probably the bulk of the metal might act as an anode, the salt water was the electrolyte, but the question of greatest interest was what constituted the cathode. Lead, copper arsenide, basic carbonate of copper, ferric oxide, nickel, carbon, cuprous oxide, and even shrimps and seaweed, had at various times been stated to promote corrosion of brass and copper by forming cathodes. The presence of air was, by many chemists, considered essential to the corrosion of brass and copper by acid or saline solutions; and it was at least certain that access of air greatly increased the speed of corrosion.

Some considered that the strongly adherent green deposit frequently found on copper increased the speed of corrosion by absorption of oxygen; some thought it acted as a cathode; while others credited it with a protective action. As to the action of stray currents, it was a fact that corrosion of condenser tubes became considerably more troublesome soon after the introduction of electric lighting on board ship; but, in spite of this and of other more direct evidence, at least one well-known authority maintained that the progress of corrosion on board ship was not affected by external currents because of the very small magnitude of the current which could be conveyed by the water in condenser tubes. Now, a comparison of the magnitude of such a current with the magnitude of the currents set up by the voltaic cells previously referred to, and which did undoubtedly cause corrosion, showed that the two were approximately of the same order, and with length of time both might effect serious corrosion. It was also possible that very small induced currents might act similarly. The presence of depolarizers in the metal or liquid might exercise an important effect on the speed of corrosion, but their influence had hitherto not received much attention. Thermo-chemical action was another possible cause of corrosion, but no experimental establishment of its action had been published. The effect of increased speed of circulation of water had not yet been satisfactorily ascertained, and but little information as to the effect of sewage and other contamination of the circulating water was available.

The methods at present employed for the prevention of corrosion in brass and copper tubes were either mechanical or

electrochemical. In the mechanical class varnishes, asphalt and special cements had been tried without much success. Metallic coatings, especially tin, lead and tin-lead alloys, were better, and a particular form of ferric oxide had stood exhaustive tests on a small scale. For brass tubes the only coating now used extensively was tin, but the layer of tin was necessarily very thin—usually not more than 1/50 mm—and, therefore, very liable to pinholes and slight defects which would result either in the tin being rapidly dissolved away or in the tube being corroded more quickly, according as the tin or the tube were the more electro-positive. The efficiency of a lead coating depended on its purity, and that of a lead-tin alloy on the percentage of tin and of the impurities, while the thickness, continuity and mode of application of the layer were also factors.

Electrochemical methods consisted in the sacrifice of a cheap electro-positive metal for the preservation of the expensive one which was negative to it, for which purpose iron and zinc were generally used. It was often stated that the iron condenser casing helped to prevent corrosion of the tubes, and in some cases it certainly appeared to do so; in others it was not effective and bars of iron or zinc were placed in the water spaces at the ends of the condenser and screwed to the tube-plate; but it appeared that the protection so afforded extended only to the tube-plate and for a short distance along the length of those tubes satisfactorily connected to it.

When bars of iron or zinc were so used corrosion of the ends of the tubes should be less than it was further along, and if this were not found to be so, the meaning would be in the case of any particular tube that it was not in good metallic contact with the tube-plate, or in general that the iron or zinc was not in good contact with the tube-plate, or that the composition of the tube-plate varied too much from that of the tubes.

The protective influence of zinc had only a limited area, and in dealing with the question of the extension of that area it was necessary to consider in detail the protective action of the zinc. If no free zinc were present the brass would tend to dissolve. Brass, however, did not dissolve as such, but its zinc passed into solution to a much greater extent than its copper. When free zinc was present and a current was passing from it to the brass there was a tendency to deposition of zinc on the brass instead of solution of zinc out of the brass, yet this tendency was only slight and no appreciable quantity of zinc was actually deposited. Nevertheless, the tendency existed, and, as it constituted the protection of the brass from corrosion, if it were enhanced the protected area might be extended. The obvious means of effecting this was to pass a small and carefully regulated current from zinc to brass, keeping the e.m.f. low—2 volts to 4 volts—to avoid waste of zinc.

Progress of Electric Smelting in Norway.

The Stavanger Electro-Staalverk—a new company having a capital of £25,000—has been promoted for the electrical production of high-grade steel from the iron and steel scrap from broken-up ships. Besides the furnaces, the works at Jorpeland will include a steel foundry, rolling mills and hammers. The available energy is 2500 hp, and the annual output is estimated at 1400 tons of first-grade steel billets, 600 tons of cast steel and 300 tons of hammered steel. The Arendals Fosse Kompagni, a similar company, which has increased its capital to £233,300, is making arrangements for taking 12,000 hp from a waterfall near Arendal, and has elected to use the Grönwall process. At the Ilen Smelting Works, at Trondhjem, experimental runs, chiefly on copper, have been made in a 1000-hp electric furnace, and it is reported that the company has definitely decided to adopt electric smelting and will shortly start an iron smelting furnace to give an annual yield of 9000 tons.

British Engineering Imports and Exports.

The Board of Trade returns for January, 1911, put the value of imports of iron and steel, including manufactures, at £825,-305, an increase of £110,689 as compared with January, 1910; exports amounted to £3,830,687, showing an increase of £351,-815. Imports of other metals, including manufactures, were £2,247,501, an increase of £16,402, and exports, £864,988, an increase of £39,575. Imports of electrical goods were £125,805 and exports £202,996, showing increases of £16,334 and £47,922 respectively. Imports of machinery reached £433,719, an increase of £99,903; with exports £2,486,083, an increase of £385,330. Imports of new ships, £9,791, an increase of £9,688; exports of ships, £230,208, a decrease of £1,910,078.

Analytical Notes.

Separation of Iron, Aluminium and Chromium.

Tcharviani and Wunder proceed by fusing the mixed oxides with sodium carbonate in a platinum crucible for seven hours; the cooled contents of the crucible are leached out with water and the iron oxide is filtered off. In the filtrate the alumina is precipitated by excess of ammonium nitrate; the filtrate from this is acidified with nitric acid, and, after the reduction of the chromate by alcohol, chromium is precipitated as hydroxide by excess of ammonia, the precipitate dissolved in hydrochloric acid and reprecipitated with ammonia. By this method the alumina is obtained in a much purer state than either by precipitation from any acid solution with ammonia or from an alkaline solution after decomposition of the aluminate by ammonium chloride.

Estimation of Small Amounts of Lime in the Presence of Much Magnesia.

In the method employed by C. Liesse the solution is diluted to the extent of 1 in 1500 when magnesium oxalate is soluble. One gramme of the substance is dissolved in 25 parts of hydrochloric acid, and after dilution with 100 parts of water the solution is made slightly alkaline with ammonia, heated, filtered, cooled and diluted to 1500 cc. Four grammes of ammonium oxalate are added, the solution is acidified with acetic acid, well stirred and allowed to stand two hours before filtering. Good results are obtained with 99.5 per cent of magnesia and 0.5 per cent of lime.

Estimation of Chromium in Chrome-Tungsten Steel.

Henrik Wdowiszewski recommends a modification of Von Knorre's method. To one to two grammes of borings in a half-liter Erlenmeyer flask 10 to 15 cc. of a 15 per cent solution of disodic hydric phosphate and then 8 to 16 cc. of sulphuric acid. sp. gr. 1.65, and 5 cc. of water are added. On gently heating the metal dissolves in about 15 minutes; the heat is then increased and 2 cc. of nitric acid, sp. gr. 1.4, are added to convert tungsten into soluble phospho-tungstic acid. After dilution of the clear liquid with 300 to 500 cc. of hot water the addition of 3 to 5 grammes of ammonium persulphate oxidizes chromium to chromic acid. Excess of persulphate is decomposed by boiling, a little more sulphuric acid is added and the chromic acid is titrated with ferrous ammonium sulphate, the excess being determined with permanganate.

A Sensitive and Stable Litmus Solution.

A. Püschel states that the sensitive violet-colored constituent of litmus can be separated from the other coloring matter, gum and inert substances contained in commercial litmus by heating with dilute sulphuric acid—4 per cent—which precipitates it, probably as a sulphonic acid. The precipitate is collected, washed, redissolved in hot water and neutralized with sodic hydroxide. The indicator thus obtained has a violet color and is extremely sensitive.

Estimation of Sulphur in Brass and Bronze.

Gustav Thurnauer obtains excellent results by the following method: Thoroughly mix 1 gramme of filings with 6 grammes of a mixture of two parts of potassic chlorate with one part sodic carbonate; transfer to a wrought-iron crucible lined with sodic carbonate, cover with more of the fusion mixture and heat gradually until fusion is complete. When

cooled, digest the mass with hot water, filter off the oxides, acidifying the filtrate with hydrochloric acid, and determine the sulphur as barium sulphate. The author admits that the error may be as much as 0.01 per cent, and adds that if great accuracy be required a silver crucible should be used. If "an error of 0.01 per cent" mean a difference of 0.01 per cent of sulphur in the metal, the inaccuracy due to the use of an iron crucible would amount to a tolerably large proportion of the sulphur present in brass or bronze of average quality.

Market Prices.—February, 1911.

Copper, with the other metals, was depressed toward mid-month. Opening at £55.5.0 it had fallen by the 8th to £54.12.6, thence recovered gradually to £54.16.3.

Tin has again been erratic, opening lower at £195 and dropping with extraordinary rapidity to £182 by the 8th, and £171 on the 9th, recovering sharply to £197 by the 15th, and has now settled again to £193.

Lead has been stronger, being slightly lower at £13.5.0 on the 8th, recovering to £13.10.0, and closing at £13.5.0.

Iron. Hematite has been down from 67/2½, dropping to 66/1½ by the 15th. It has recovered, however, to 67/1 and present transactions rule rather lower.

Scotch Pig has also been down, touching 55/- on the 15th and 54/- on the 18th, and only recovering to 55/1½.

Cleveland Warrants are in sympathy, dropping to 48/11½ by the 15th and only showing 48/11 on the 25th.

Platinum, per oz...£8 6 6
Alum, lump, loose, per ton........................ 5 12 6
Antimony, black sulphide powder, per ton..........22 0 0
Borax, British refined crystal, per ton........:....16 0 0
Sulphate of ammonia, f.o.b. Liverpool, per ton......14 2 6
Sal ammoniac, lump, firsts, delivered U. K., per ton...42 0 0
Copper sulphate, per ton.............................19 17 6
Caustic soda, ash 48 per cent, ordinary, per ton...... 5 10 0
Litharge, flake, per ton.............................15 10 0
Sulphur, recovered, per ton.......................... 5 0 0
Camphor, 1-oz. tablets.............................. 1 10
Shellac, standard T. N. orange spots, per cwt........ 3 12 0
Copper ore, 10 to 25 per cent, unit..............9/3 to   9 0
Tin ore, 70 per cent, per ton.....................£123 to £125
Carbolic acid, liquid 97/99 per cent, per gal.......... 1 4
Creosote, ordinary good liquid, per gal............... 2
Naphtha, solvent, 90 per cent at 160° C., per gal...... 9
Petroleum, Russian, spot, per gal............4⅞d. to   5
Mica, small slab, original cases, per lb..........6d. to   1 0
India rubber, Para fine, has risen fairly steadily throughout the month, 5/6 to 6/1 by the 8th, 6/11½ by the 22d, and closes at 6/9.

During the month the following differences are noted:

Lower.	*Amount.*		
Copper	£	9	0
Tin (unsteady)	3	0	0
Scotch pig			6
Cleveland Warrants			3
Shellac		12	0
Higher.			
Lead		2	6
Sulphate of ammonia	1	0	0
Copper sulphate		12	6
Camphor			3
Tin ore	7	0	0
Carbolic acid			4
Para rubber		1	6
Platinum		8	0

The Camp Bird., Ltd., will in the future issue a monthly statement showing the monthly earnings of the company from its Camp Bird mine and from the holdings in Santa Gertrudis, Mexico. For the month of December, 1910, the estimated earnings applicable to profit are $112,161.

Recent Metallurgical Patents.

Gold and Silver.

Antimonial Gold Ore Treatment.—A new proposal for the treatment of gold-bearing antimony ores is made by John Jones and H. S. Bohm, of Mount Morgan, Queensland, Australia. They claim that aside from being effective for the purpose, the process also is economical by reason of the possibility of regenerating the chemicals used.

A hydrochloric acid generator and tower are part of the plant. The first treatment is with HCl, and as the ore is a sulphide the action of the HCl on the ore is to form H_2S. In another operation the chloride solution of antimony is electrolyzed, generating chlorine which is used to combine with the H_2S formed in the first instance to regenerate HCl, according to the equation $H_2S + Cl_2 = 2 HCl + S$. The regenerated hydrochloric acid gas is returned to the tower for enriching the solutions.

The cycle of operations proposed is as follows: The pulverized ore is agitated in a dissolving vat with hydrochloric acid solution, heated by exhaust steam or other means. The generated H_2S is conducted to a regenerating chamber where it combines with Cl conducted from the electrolyzing cell, to be referred to later. When the antimony has been dissolved, the solution is filtered and transferred to the electrolyzer, fitted preferably with carbon anodes and antimony cathodes. The Cl from the cell is conducted to the regenerator mentioned above where it combines with the H_2S. The sludge from the first treatment tank contains the gold and other valuable metals, and may be treated in any suitable way, preferably by clorination. (984,090, Feb. 14, 1911.)

Copper.

Hardening Copper.—The much sought process for so hardening copper that it can be used for purposes for which it is not now fit is claimed by R. A. Hamilton and Joshua Henry, of Connellsville, Pa. The treatment enables the copper to be manipulated in the ordinary rolling or hammering processes without losing any of its stability or hardness. The hardness may be varied to any degree required. In carrying out the invention the first step is to heat metallic aluminium in a crucible to a high temperature, and add iron pyrites in sufficient quantity to form a mixture that is brittle under the hammer. The aluminium and pyrites are thoroughly mixed while highly heated, and the resulting uniform mixture poured into convenient molds. To harden metallic copper a suitable quantity of the aluminium-pyrites mixture is added to molten copper, together with a small quantity of borax and charcoal. From 1 oz. to 3 oz. of the aluminium compound is used to each pound of copper. Borax and charcoal are added in quantities of ½ oz. each. After the ingredients have been added the crucible is heated until the constituents of the molten mass have become thoroughly combined, when the metal is poured into suitable molds. (984,137, Feb. 14, 1911.)

Neutralizing Smelter Fume.—In a patent recently granted to Clarence B. Sprague, of Salt Lake City, Utah, and assigned by him to the United States Smelting, Refining & Mining Company, is described the method used at the company's plant near Salt Lake City for the purpose of removing sulphuric acid and noxious solid fume from roaster and furnace gases. It has long been known that owing to the presence of sulphuric acid in the roaster and furnace gases from copper smelters the bag-house system of condensing fume was not applicable, owing to the ready destruction of the bags. Mr. Sprague has sought to make these gases amenable to bag filtration by neutralizing the acid therein contained, after which the bag can remove the solid fume, some of which is noxious, as arsenic, and some of which is valuable, as metallic particles. His preferred means of neutralizing the acid is by introducing zinc oxide fume into the gas flues before the gases reach the bag house, although he suggests that the same result can be

accomplished by roasting or smelting with the regular charge a suitable quantity of zinc ore, which in oxidizing will give a basic element to combine with the acid element in the fume to form a neutral salt that will be without effect on the bags. By this scheme it is sought to eliminate trouble from the damage of crops and animals by the discharge of acid gases and noxious fumes onto the agricultural region surrounding the smelter. (984,498, Feb. 14, 1911.)

Aluminium.

Improved Process of Manufacture of Aluminium Alloys.— It has been found difficult to produce a composite metal containing an appreciable quantity of aluminium and having the properties of malleability and ductility. Messrs. J. G. and W. F. MELLEN, of Bridgeport, Conn., have, however, recently patented a process which they claim enables them to produce an aluminium alloy with copper or other metal which does have the properties mentioned. Their process gives an alloy with lowered specific gravity and color modified by aluminium. As a general proposition it may be stated that the greater the proportion of aluminium in the alloy the lighter will be the composite metal both in color and weight and also the harder and less malleable and ductile.

In carrying out the process the copper, or other foundation metal, is weighed and melted in a pot. When the temperature has been raised to the proper point a suitable quantity of aluminium is added and immediately after it has melted a suitable oxidizing agent, such as potassium bichromate, and a suitable flux, such as borax, are added in proportions of about ½ lb. bichromate and ¼ lb. borax to each 100 lb. of alloy. A furious action ensues owing to the oxidation of the aluminium, which brings about an intimate mixture of the metals, the union of oxygen and aluminium causing atomic as well as molecular activity. The action of the borax is to dissolve the oxides as fast as they are formed, and in this way the full benefit of the oxygen is used and the objectionable oxides removed. If the oxidizing agent and flux are added before the aluminium the resulting alloy will be harder; if after the aluminium the alloy will be more malleable and ductile.

Variations in the procedure are described, but the main point to the process is the production of an intimate mixture of the elements of the alloy, a failure to obtain which has been the cause of former unsatisfactory alloys of aluminium. (982,218, Jan. 17, 1911.)

Detinning and Degalvanizing.

A cyclic method for removing tin and zinc from tinned and galvanized iron scraps has been patented by ALEXANDER S. RAMAGE, of Newark, N. J. His preferred procedure is to form a solvent of sodium plumbate by dissolving lead ashes or litharge in boiling caustic soda. This solvent is contained in several tanks. Iron cages containing tin scrap are then lowered into the bath, whereupon spongy lead is thrown out of solution, being replaced by tin, forming sodium stannate. It is preferable to have several tanks of sodium plumbate solvent so that after the operation is under way the clean tin scrap is treated in the weakest plumbate solution to insure the complete precipitation of the lead, and finished in the strongest plumbate solution to insure the removal of the last of the tin. The spongy lead is sold as such for storage battery or other purposes.

The sodium stanate is then used as a solvent bath for galvanized scrap, whereupon similar reactions ensue, precipitating tin as metal and dissolving zinc, forming sodium zincate. The tin is used to make tin salts, while the sodium zincate is electrolyzed in cells, using iron anodes and thin sheet zinc cathodes. All of the zinc is not precipitated, and the solution is used for the further dissolution of lead to repeat the cycle. The inventor states that the presence of sodium zincate does not militate against the successful use of the process. (983,931, Feb. 14, 1911.)

Synopsis af Metallurgical and Chemical Literature.

Iron and Steel.

The Electric Furnace in Siderurgy.— The January issue of the *Proceedings* of the Engineers' Society of Western Pennsylvania contains an interesting and instructive paper by Mr. P. McNIVEN BENNIE on the present status of the electric furnace in the iron and steel industries. A review is first given of the production of pig iron in the electric furnace in California and Sweden, and the principal types of electric furnaces are next sketched. The author distinguishes the following three general classes: (1) arc furnace heating by radiation (Stassano); (2) arc furnaces in which the current passes from the electrodes in the bath (Girod, Heroult, Keller) and (3) induction furnaces (Colby, Kjellin, Roechling-Rodenhauser). The different uses of the electric furnace in the steel industry are enumerated as follows: First, as to high-grade steel, of crucible quality, the electric furnace is designed to become a serious rival of the crucible method, simply because it is less expensive. Secondly, for steel castings, the electric furnace promises to appropriate to itself a considerable field. It cannot and does not aim to displace open-hearth steel castings; but for a grade of castings somewhat better than open-hearth product, cheaper than the crucible product, and for which there is even now a crying need the electric furnace has found a place in which its popularity is certain to increase. Third, the electric furnace is not claiming rivalry with the bessemer or open-hearth furnace as a steel producer for ordinary grades of structural and similar steel. Rather it is to be considered as a useful accessory or ally of the older methods. It offers an opportunity to do additional refining or special treatment in an expeditious manner secondary to other operations. As to the refractories required the author refers to the possibilities of electrically fused alumina,* making a brick that is fairly inactive chemically at furnace temperatures and this material gives great promise. Generally the roof has been short-lived in the larger steel furnaces, probably due to the chemical activity of lime, silica and iron vapors in the furnace. Any refractory material that will stand the high temperatures and prolong the life of the roof will mark another step forward. The author finally points out that in the electric furnace with a non-oxidizing atmosphere chemical reactions are possible which differ from those in the ordinary oxidizing metallurgical furnaces. He refers especially to the removal of sulphur as calcium sulphide and the removal of phosphorus as phosphide. In the extended discussions which followed Mr. P. P. Reese said that "one of our troubles is in keeping the roof on the furnace. We used a 9-inch silica brick and we tried a 13-inch silica brick and we did not get any more life out of the latter than the 9-inch. I think it is due partly to what Mr. Bennie said, the action of the lime fumes on the silica, but I think it is mostly due to the reflection of the arc. We can string the furnace roof in one heat. We do not do it as a rule, because we try to glaze the roof first. But the roof on the furnace is quite a problem just now. With our side walls we have very little trouble." The speaker appeared to hope that the fused alumina brick would solve the problems. As to the cost of power, Mr. N. W. Storer made the interesting statement that he knew of one power plant in operation at the present time where the cost of power, generated by steam, is less than ¼ cent per kilowatt hour.

Gold and Silver.

Effect of Heat on Precipitation.— At the Knights Deep cyanide plant in South Africa waste heat from the power plant is used to raise the temperature of solutions before precipitation in zinc boxes. In the December, 1910, *Journal* of the Chem. Met. and Min. Soc. of South Africa, Mr. F. D. PHILLIPS presents figures showing the improvement in extraction due to

*See article on Alundum Refractories, page 225.

the warming of solutions, especially during the winter months.
Before Utilizing Waste Heat.

	KCN.	NaOH.	Assay value entering boxes, dwt.	Assay value leaving boxes, dwt.	Tons solution per cubic foot of zinc per 24 hours.	Temperature at head of boxes, deg. Fahr.
June, 1908	0.010	0.0140	0.331	0.033	1.58	56.4
July, 1908	0.010	0.0150	0.336	0.041	1.42	53.8
August, 1908	0.011	0.0140	0.357	0.033	1.59	57.2
Average	0.010	0.0140	0.351	0.036	1.53	55.8
After Utilizing Waste Heat.						
June, 1909	0.008	0.0140	0.412	0.010	2.08	73.8
July, 1909	0.006	0.0157	0.381	0.015	2.17	76.3
August, 1909	0.006	0.0156	0.362	0.013	2.16	77.4
Average	0.007	0.0151	0.385	0.013	2.14	75.8

It will be seen that the average temperature was raised 20°
Fahr. An important point is the increased amount of solution
that was precipitated per cubic foot of zinc in 24 hours and the
smaller consumption of cyanide. The flow was greater and the
results better with heat than without. The heated solution also
was responsible for the comparative absence of white precipi-
tate in the boxes.

Explosion in Amalgam Barrels.—The danger attending
the use of barrels in grinding black sand and other rich prod-
ucts in cleaning up the mill is mentioned by W. R. Dowling
in the December, 1910, *Journal* of the Chem. Met. and Min.
Soc. of South Africa. It seems that at times gas is generated
in the barrel and escapes with considerable violence when the
barrel is opened. Several unfortunate accidents have occurred
from this cause, even after the barrel had been opened for
some time. There was still enough gas left to form an explo-
sive mixture when ignited by a candle used to inspect the bar-
rel and its contents.

The cause of the trouble appears to be that gas is generated
when acid material containing partly oxidized pyrite is treated.
The finely divided iron produced from the cast-iron barrel and
the steel balls being ground in the presence of pyrite results in
the formation of ferrous sulphide. Ferrous sulphide and finely
divided iron acted on by the acid of the charge form sul-
phuretted hydrogen and hydrogen, according to the equations:

$$FeS - H_2SO_4 \; FeSO_4 - H_2S$$
$$Fe - H_2SO_4 \; FeSO_4 - H_2.$$
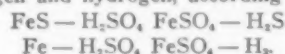
This mixture of gases is explosive, as has been proved when
a barrel was inspected after opening, using a naked light. The
remedy to prevent excessive pressure is to use sufficient lime
with charges to neutralize the acid. Care should be exercised
to open the barrel carefully, and if possible it should be pos-
sible to open it at two points so that a current of air could cir-
culate through it and remove any collection of explosive gases.
It has been found that when an excess of lime is used there is
little or no pressure developed; indeed, in one instance there
was a slight vacuum.

Copper.

Copper Blast Furnace Tops.—The introduction of acid
making at the copper smelting plant of the Tennessee Copper
Company has brought about some interesting developments in
the construction of blast-furnace tops. The February, 1911,
Bulletin of the American Institute of Mining Engineers con-
tains an illustrated history of the developments which have
led to the adoption of a special top. The article is by Mr.
N. H. Emmons, of the Tennessee Copper Company.

The troubles with the old-style brick-top furnace, supported
by structural steel, began when the acid plant was connected
with the furnace flue and a damper put in the flue to force
the gas into the acid plant. For a few months the tops were
tight and worked satisfactorily, but it was then found that they

would not stand the temperatures, particularly when dampered
back to force the gas into the Glover towers. The steel skele-
ton of the top warped and became unsafe.

The first new top made was low, with brick-lined flues at
each end below the feed floor leading to the main dust cham-
ber. The top was made of 18 ribbed copper castings in the form
of a grid in which firebrick were laid. The copper ribs pro-
jected above the brick and thus provided for radiation of the
heat, which at times reached 1800° Fahr. to 2000° Fahr. The
whole top was hung from a structural steel frame. The top
of this furnace proved to be too low and allowed smoke, fume
and flame to shoot out of the charging doors when opened
for charging or barring.

The next attempt was similar, but the top was higher, and
the flues larger. Above the floor the flue connections were
made of water jackets, but these were not at all satisfactory
and a connection was made to the main blast pipe and air at
45 oz. pressure blown through the jackets. This answered very
well. Both of these types gave satisfaction as far as con-
cerned the temperature of the gases and making repairs, but
the gas flues were so small and low that pieces of the charge
would be blown into them and cause accretions, which reduced
the flue area so that gas and smoke would issue from the
charging doors.

The latest development is a tubular-top furnace. It has cast-
iron corner posts and dividers with walls and ends laid up with
firebrick. The half-circle top is supported on 20-in. I-beams
resting on the columns. All metal parts are exposed to the air
for cooling. The area of the flues totals 64 sq. ft., being more
than twice the area of the flues of the first furnaces con-
structed. This top is expensive to build, and it is thought it
will be expensive to maintain.

Recording pyrometer charts are shown in the original paper
giving the temperatures in the horizontal flues from two of the
furnaces and at the base of the Glover towers. A peculiar
point noted is that the temperature at the towers is higher than
in the furnace flues. Since there must be some loss by radia-
tion in the flues the only way to account for the higher tem-
perature at the towers is that the furnace gases contain some
unburned sulphur and carbon monoxide which, in burning in
the flue, give rise to the higher temperature at the base of the
towers. The temperature at the Glover tower is very uniform,
showing the equalizing effect of the dust chamber. For the
month of September the average gas at the foot of the Glover
tower showed 0.16 per cent more SO_2 than the average of
furnaces 4 and 5, and a drop of temperature of 52° Fahr.
below the average of the furnaces recorded at the furnace top.

Reverberatory Furnace Hearth Construction.—We take
the following description of the construction of a chrome bot-
tom from an article entitled "Engineering in Metallurgy," by
Messrs H. Schroeder and W. E. Longworth in the *Australian
Mining Standard* of Feb. 1, 1911. The entire article runs
through several issues and gives a complete engineering de-
scription of the works of the Electrolytic Refining & Smelting
Company of Australia.

The reverberatory smelters are 34 ft. x 17 ft. at the hearth.
The walls and casing plates are carried on concrete foundations
2 ft. 6 in. deep, a layer of concrete 12 in. deep being laid under
the hearth. A course of red brick, laid flat, covers the con-
crete, and on this is placed a layer of "brasque," 6 in. deep at
the center and shaped according to the template of the hearth.
The brasque is a mixture of fireclay, crushed coke and sand,
moistened and tamped into place. On this a 9-in. course of
local firebrick was laid, followed by a 9-in. course of Scotch
firebrick. The furnace walls were then built up, the first three
courses being stepped out 1.5 in., the following three being
stepped back, and the wall then worked straight up to the roof.
By thus stepping the walls out a ring was formed to hold
down the working bottom, which was a mixture of chrome iron
ore and fireclay, tamped to a thickness of 6 in. in the center

and shaped according to the template, the invert being 8 in. at the center.

The chrome bottom was put on thus: Chrome iron ore, crushed to pass a 1/8-in. screen, was mixed with fireclay in the proportion of 3 to 1, by bulk. This was mixed with water to the consistency of a cupel mixture, spread over the bottom in 1/2-in. layers and tamped with hot irons. The resulting layer was only about 1/8 in. thick, so that 48 layers had to be put on to give the necessary thickness of 6 in. It required seven men, working eight hours per shift, 13 shifts to put in a 34-ft. x 17-ft. chrome hearth, building the sides about 9 in. higher than the center. Seventeen tons of crushed chrome ore and 3.5 tons of fireclay were used. The cost of the labor was about $170. Such a bottom, however, once made is good for all time, and there is practically no absorption.

Electric Furnaces.

The Pinch Effect for Agitation and Proportioning of Electrodes for Electric Furnaces.—A French patent of Mr. CARL HERING (French patent 419,715, June 28, 1910, under international convention, July 6, 1909) is abstracted in the *Journal* of Society of Chemical Industries, February 28, as follows: "The furnace has a bath of melted material and an electric current, proportioned with reference to the transverse section of the material is passed through a mass of molten material in communication with the bath, thus producing in an automatic manner a continuous agitation of the material, owing to the so-called 'pinch' effect. The electrode is provided with a resistance (meaning evidently the dimensions of the electrode are chosen so that it has a resistance), such that the heat developed in the electrode by the current transmitted through it is equal to double the loss of heat by conduction through the electrode when the current is not passed. (In this case practically no heat will pass in either direction through the electrode and within the furnace.) In a modified form of the process one or more arcs are introduced into the furnace between parts of the melted material."

Amorphous Carbon Electrodes and Brushes.—British patent 3336, March 2, 1911, of the British Thomson-Houston Company (communicated by the General Electric Company of this country) is abstracted in London *Electrical Engineering* of March 9 as follows: "Brushes or electrodes of increased density and mechanical strength and of high conductivity are produced by moulding from a mixture of carbon and a carbonaceous binder and baked to a temperature of 480°C. They are then impregnated with pitch or other suitable material and fired to a temperature of about 1,400°C. The following result is given as an example: apparent density, 1.66; absolute density, 2.05; porosity, 19 per cent; resistance, 0.00108 ohm per inch cube; tensile strength, 2,130 lb. per square inch.

A revolving reverberatory copper furnace has been patented by J. A. Brown, of Sydney, Australia. It consists of a barrel-shaped furnace, with firebox or gas producer at one end, and an exhaust gas chamber at the other. The exhaust gases are used to preheat air, which is conducted to the fire end of the furnace, where it is mixed with the fuel gas and directed in a blast onto the ore charge in the furnace. As the furnace revolves, every part of the charge is exposed to the heat. The charge is fed at the fire end, and the slag flows into a settler placed in the exhaust gas chamber at the other end. A tap hole is placed in the side of the furnace at its widest part, and through this the accumulated matter may be tapped.

Bromo-cyanogen as an adjunct to the regular cyanide process is prepared, according to Australian practice, by first dissolving the bromine salts in water, then adding the potassium cyanide and finally, when all the salts are dissolved, sulphuric acid is added and the mixture stirred for several hours. The charge is then ready to be added to the pulp for extraction of the gold.

Smoke Abatement Lectures at Liverpool, England.

A course of evening lectures and demonstrations for persons in charge of the furnaces of boilers and other heating appliances was commenced in Liverpool on Friday, Jan. 27. Dr. Hope, medical officer of health for Liverpool, and Professor Watkinson, professor of engineering at the Liverpool University, co-operated in arranging this course of instruction with reference to smoke abatement. The fee for the course of six lectures is 5 shillings, and 63 students, chiefly working firemen and engineers, have registered their names and are now attending these lectures. The lectures are delivered at the School of Hygiene, and are under the control of the sanitary science instruction committee of the Liverpool Corporation.

The first lecture of the course was delivered by Dr. W. L. HAWKSLEY, one of the assistant medical officers, who dealt with the importance of pure air in relation to the health of the community and with the reforms necessary in order to obtain a purer atmosphere. Commencing his lecture with a reference to the select committees appointed in 1819, in 1843, and again in 1845 to inquire into this question, and to their findings and recommendations, Dr. Hawksley passed on to consider the reports of Dr. Lyon Playfair and Sir H. de le Beche, and the results of the first Smoke Abatement Exhibition of 1881.

The question of domestic smoke was then dealt with by the lecturer, and the connection between smoke and fog was traced and emphasized. The lecturer explained the differences between town and sea fogs as being due to the dirt and soot and tarry vapors suspended in the former. The effects of a smoky atmosphere upon health were next discussed, the differences between healthy and unhealthy persons in this respect being pointed out. The damage done by smoke to the stonework of public buildings was also touched upon, and the monetary loss this entailed was emphasized. Dr. Hawksley closed an interesting and instructive lecture by giving an account of the aims and work of the Smoke Abatement League of Great Britain, and with a summary of the speeches made by the deputation arranged by this league, which waited upon Mr. Burns at the local government board's offices in London on June 29, 1910.

The second lecture was delivered on Feb. 3 by Mr. JOHN B. C. KERSHAW, who took as his subject "solid fuels and the scientific principles of combustion."

Dealing first with the origin of solid fuels the lecturer stated that these had been formed by the decay of wood and other vegetable matter in the presence of moisture and heat, great pressure also having been gradually added to these two agencies in the latter stages of the process of conversion. An interesting table showing the chemical composition of wood, peat, lignite, bituminous coal, semi-anthracite and anthracite was exhibited, and it was pointed out by the lecturer that during the successive stages of the gradual change from peat to anthracite the carbon in the fuel increased from 52 per cent up to 94 per cent, while the gaseous constituents—nitrogen, oxygen and hydrogen—diminished in similar proportion. Reference was then made to the formation of the coal fields of southwest Lancashire and to the clear proof which existed that the basin of the Mersey was once a vast inland swamp, with a belt of forest land stretching across what is now the Mersey Bar. The remains of this forest are still to be found on the shore near the surface at Hoylake and at Formby.

The changes which occur when bituminous coal is heated were next discussed, and it was stated that the large volume of hydrocarbon gases which are liberated from this class of coal forms the chief difficulty in burning bituminous coal without smoke, since great absorption of heat occurs during this stage of the combustion process, and the liberated gases require careful and scientific management to avoid smoke formation.

The three essential conditions for obtaining the smokeless combustion of bituminous coal were stated to be: (1) A sufficiency of air supply; (2) a sufficiently high temperature;

and (3) a good mixture of the air and of the hydrocarbon gases.

It was pointed out that, although a Liverpool engineer, C. Wye Williams, clearly demonstrated that these conditions were absolutely necessary 70 years ago, the designers and builders of boiler furnaces to-day still too often neglected them and designed and erected furnaces in which one and often all of these essential conditions of good combustion were absent.

The causes of factory smoke were then stated to be: (a) Too little boiler power, leading to overworked boilers; (b) unscientific management of the boiler fires; (c) neglect or ignorance on the part of the designers of the furnace of the essential conditions of good combustion.

The lecturer closed by stating that all the smoke arising from the use of coal for industrial purposes might be abated, and in time gradually abolished, if those who control our works and factories would study the matter scientifically, and see, as far as possible:

(1) That they possessed adequate furnace and boiler equipment for the work required.

(2) That the furnaces were properly designed and that no cold or water-cooled surfaces came into contact with the hot gases before combustion was completed.

(3) That the boiler or furnace plant was under proper scientific control.

(4) That the firemen were well paid and were given an interest in their work by payment of a bonus for good results.

(5) That the chimney top was visible from the firing places of the furnaces or boilers.

The lecture was illustrated by experiments.

The third lecture of the series was delivered on Feb. 10 by Mr. Kershaw, his subject on this occasion being the examination of the waste gases and control of the combustion process.

Prof. Watkinson, Harrison professor of engineering at Liverpool University, delivered the fourth of the lectures for stokers and others interested in furnace management in the Lecture Theater of the Walker Engineering Laboratories at Liverpool, on Friday evening, Feb. 17, taking as his subjects, the setting and construction of boilers and furnaces, and the methods of producing natural, forced and induced draught.

After a few opening remarks dealing with the general aim and purpose of the lectures, and with the importance of accurate measurements of draught, temperature, pressure and of the composition of the exit gases as an aid to good work in boiler management, the lecturer dealt with the three conditions (see lecture II above) requisite to obtain good combustion of solid bituminous fuels and showed experimentally how essential these were to smokeless combustion.

The details of construction of internally fired or Lancashire boilers were than illustrated by aid of lantern slides to prove the difficulty of obtaining smokeless combustion due to the small furnace and to the arch of water-cooled plates over the furnace grate. The purpose of the bridge in this type of boiler was then discussed, and it was proved that it produced eddies in the gases as they passed over it into the flue beyond and therefore tended to promote mixture of the hot air and hyrocarbon gases given off from the burning fuel. A high bridge was, therefore, better than a low one, if sufficient draught could be obtained to work the boiler fires with it. In the absence of good draught the use of steam jets was often resorted to in order to (1) increase the air supply, and (2) to promote the better mixture of the air and furnace gases.

In the Bellville type of marine boiler air at 30 lb. pressure was employed in place of steam, and the Howden system of forced draught was now generally employed for marine work, but this system has not been adopted to any extent for boiler installations on land.

Natural draught produced by a chimney rarely exceeded ½ in. to ¾ in., measured by a water gage. This low draught limited the thickness of the fires and rendered it exceedingly difficult to keep the fuel on the furnace bars free from holes.

For good combustion with thick fires, on the other hand, forced or induced draught was essential, and this was now generally recognized and adopted.

The different methods of obtaining artificial draught were then discussed and the comparative advantages of steam jets, air jets and fans were dealt with by the lecturer. As compared with steam jets, fans were more costly to install, but saved largely in running costs—a good fan requiring only 5 per cent of the steam produced in place of the 10 per cent to 12 per cent used by steam jets. Makers' statements that steam jets only consumed 3 per cent of the steam were said to be absolutely inaccurate.

The different methods of furnace construction and the use of firebrick arches for conserving heat and promoting good combustion were then dealt with. It was pointed out that a firebrick arch, by increasing the heat of a furnace, may actually increase smoke production, owing to the greater rapidity with which the hydrocarbon gases will be evolved from the newly charged fuel, unless precautions are taken to greatly increase the air supply at the same moment.

The Dutch-oven type of furnace construction for Lancashire boilers was condemned by Professor Watkinson, because from 40 per cent to 60 per cent of the heat transfer in this type of boiler is by direct radiation to the plates from the glowing solid carbon lying in the bars of the grate and this radiation can only occur to the full extent when the furnace is inside the boiler. Luminous flames radiate heat also, but not to the same extent as glowing solids. Although steam boilers can be worked efficiently with gaseous fuel they require to be specially constructed for this duty, and no ordinary type of boiler will give high efficiency with external furnaces or with producer gas. The use of economizers was finally discussed and the two chief types were described.

The lecture was illustrated by numerous experiments and lantern slides and was followed by an exhibition of apparatus for making draught, temperature and other measurements incidental to good boiler management.

On Wednesday, Feb. 22, a large number of the members of the class paid a visit to the boiler installation at Messrs. Bibby's Seed-Crushing Works in Liverpool, under the guidance of Mr. Kershaw and Chief Smoke Inspector J. Macaulay.

A Novel Development in Laboratory Burners and Furnaces.

By Chester G. Fisher

No piece of apparatus has become so commonplace in the laboratory as the burner, yet it has gone for years practically unaltered. This is really remarkable, when we consider that thousands of chemists and metallurgists have time and again tried to "push" the burner in an endeavor either to hurry an operation or to obtain a little higher temperature than the design of the burner permitted. It has remained for Dr. Méker, a French scientist, to question the use of the Bunsen burner and to prove it both inefficient and extravagant.

The ideal burner must produce the hottest flame possible with minimum consumption of gas, which flame should also be homogeneous. In order to do this, problems similar to those which present themselves in the gas engine must be solved. First, the valves and passages must fill the cylinder with a homogeneous mixture of gas and air in the proper proportion for perfect combustion. Second, all obstacles which retard the operation must be done away with, in order to allow the burnt gases to quickly pass off and the cycle to be repeated immediately.

A study of perfect mixtures soon showed quite a difference in the proportion of air, depending upon the kind of gas used, which settled the fact that burners of different designs must be used for artificial, natural and gasoline gases. A burner with an adjustable gas supply, such as a needle valve, would

not do, as the proper adjustment would be guesswork; furthermore such a valve would throttle the gas supply badly. Experiments proved that six parts of air to one part of coal gas made a perfect mixture, while the proportion prevailing in the ordinary Bunsen burner was two and one-half parts of air to one part of coal gas.

It might be explained that six parts of air to one of coal gas could not be used in the Bunsen burner, as this is a highly explosive mixture and the flame instantly "fires back." The lack of sufficient air for complete combustion in the Bunsen burner accounts for the cold cone in the center of the flame, as the extra air necessary is only obtained on the outside of the flame.

Dr. Méker, after experimenting with innumerable designs and after much painstaking work, finally perfected a burner using the perfect mixture. In his burner the gas enters the bottom and the air at the sides through many large inlet holes, the

FIG. I.—COMPARISON OF MEKER BURNER AND BUNSEN BURNER

two are thoroughly mixed in the special shaped tube and pass up at a high rate of speed. The "back firing" of the flame is prevented by a nickel grid at the top of the tube; this grid is about 10 mm thick and has openings about 2 mm square. The openings being large do not impede the flow of gas, yet the flame cannot flash back, as the deep grid is comparatively cool on account of its depth.

The result is a large homogeneous hot flame made up of numerous small flames, and the unusual effect is noted by comparing the temperatures of the different parts of the Méker flame with that of the Bunsen flame, as shown in Fig. 1. The temperatures given in this photograph were measured with a Le Chatelier thermo-couple 2/10 mm in diameter.

It will be observed that the coldest part of the Méker flame is hotter than the hottest point of the Bunsen flame, that the Méker flame is almost uniform, and that the same very high temperature prevails across the large diameter of the flame. The uniform flame produced by the Méker burner has still another great advantage in that it does not produce irregular

expansion in glass or porcelain vessels being heated and, therefore, greatly reduces the risk of breakage. From the above photograph one can readily understand why a large-size Méker burner will replace a Bunsen blast lamp.

Dr. Méker was not satisfied with designing the improved type of burner but also designed an equally efficient furnace with which to use these burners. The combination of an ordinary Méker burner and a Méker crucible furnace enables gold, silver and copper to be melted without the aid of compressed air and this is done as readily as water is boiled with an old-style Bunsen burner.

It naturally followed that if such a large increase in efficiency could be obtained without blast an equally large increase could be shown over the Bunsen blast lamp when compressed air was used with the Méker burner. Dr. Méker also designed along the same scientific lines a burner using compressed air, with the result that this burner of ordinary size melted 105 grams of platinum in 17 minutes.

In combining the Méker blast burner with a furnace it was found that special high refractory clay had first to be prepared for use in lining the furnaces.

Melting Gold, Silver and Copper Without Blast.

Fig. 2 shows a plumbago crucible, which has been heated in a specially designed furnace, wherein the flame from the Méker blast lamp is made to circle around the crucible. The plumbago crucible (Fig. 2) shows the blistered effect due to the boiling out of the clay used in its construction. The four
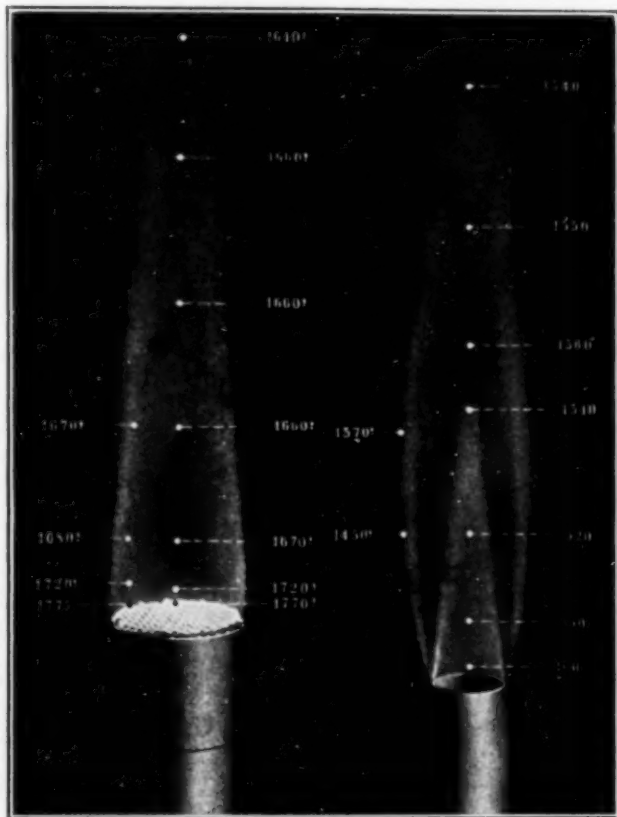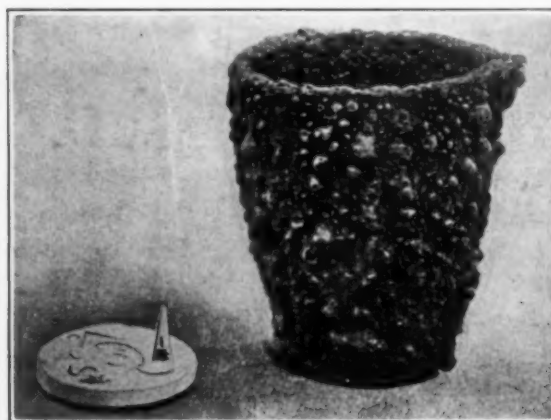

FIG. 2.—TEST OF PLUMBAGO CRUCIBLE.

pyrometric cones shown beside the crucible were in it when it was heated. It is seen that three cones have fused, including one melting at 1770° C., and the only one standing had a fusing point of 1810° C.

The results of official tests made by the Société Technique de l'Industrie du Gaz are as follows:

Test No. 1: Consisted of measuring the consumption of gas necessary to bring to a boiling point 6 liters of water, with a Méker and with an ordinary Bunsen burner, both regulated to about the same gas consumption per hour. With the Bunsen burner the boiling point was reached after 27 minutes, 40 seconds, and the total consumption of gas was 305 liters. The Méker burner heated the same volume of water to a boiling point in 22 minutes, 30 seconds, and consumed 223 liters of gas. This shows a result in favor of the Méker burner of 23.3 per cent in time consumed and a saving of 36.7 per cent in gas by the use of the Méker burner.

Test No. 2: Consisted of bringing a crucible up to a high temperature, at first with a Bunsen blast lamp (gas and air), afterwards with an ordinary Méker burner without air blast. The temperature obtained in both cases was 1060° C. The Bunsen blast lamp consumed 543 liters of gas, while the Méker burner consumed only 273 liters. The temperature obtained was measured with a thermo-electric couple and a standardized

galvanometer. This shows a waste of 98 per cent in gas consumption by the blast lamp over the Méker burner, with considerably less labor for the operator of the Méker burner and greater regularity of temperature, arising from the discarding of the air blast.

Other burners of different shapes and designs are made, in order to meet the conditions ordinarily found.

In view of the large amount of work done by Dr. Méker in perfecting these burners, it was very fitting that the Société Technique de l'Industrie du Gaz concluded its report as follows: "Considering that the burners of Dr. Méker permit of working in ranges of temperature formerly impossible to obtain, and thus contribute, both in the laboratory and in the industrial world, to the increased usefulness of gas, the committee has decided to reward the inventor by awarding him the diploma and silver medal of the society."

These burners and furnaces are now placed on the market in this country by Dr. Méker's American agent, the Scientific Materials Company, Pittsburgh, Pa.

Thermit Repairs of Caustic Pots.

By Thos. M. Skinner, Jr.

In the repairs of caustic pots by the thermit process it is of great importance that an alloy be used which will not be affected by the sodium hydrate which is fused in these pots, and for this purpose I find 50 per cent ferro-silicon to be very satisfactory, as it makes the thermit steel in the weld resemble the cast iron of which the pots are made. In using ferro-

FIG. I.—CAUSTIC POT SETTING, DIRECT FIRED WITH SLACK COAL.

silicon, 3 per cent based upon weight of thermit has proved the most satisfactory proportion.

Defects in these alkali pots usually develop at a distance about one-third up from the bottom, where the heat is chiefly applied. This position makes it very difficult to place a form to handle the thermit pour. An additional form is necessary on the outside of the pot amply large to cover all possibilities of the thermit spreading in its molten state and thereby missing the form.

A very good method which has been tried and found successful is to build the inside form in which the pouring is made by filling the hole as usual with wax; then as the pot is of circular shape, take a piece of asbestos (⅛ in. thick) cut about ½ in. larger than the hole to be mended and laid over wax and hole; then places are cut for pouring hole, riser, and preheating hole as wanted and wooden plugs placed where said holes are desired. Then the form is filled with fireclay, pounded firebrick and sand in equal parts. The wax is melted out by a torch and is caught below as it comes out of preheating hole. The sheet of asbestos serves not only to keep the fireclay from making an uneven surface, but gives a clean, smooth job without any slag adhering, which would compel a

great amount of chiseling afterwards.

By this thermit process of mending our caustic pots we have been able in many instances to make worthless pots practically as good as new, thereby extending in a very economical way the life and usefulness of these pots.

Green River, Wyo.

The Development and Varied Application of Oxygen Rescue and Reviving Apparatus for Mines, Metallurgical and Chemical Works

By Dr. Henry M. Payne.

When the need of conveniently portable rescue apparatus first became apparent in the mining districts of Europe several types were developed, in all of which great difficulty was experi-
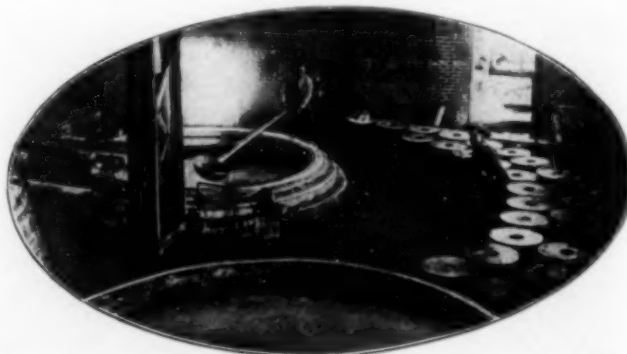

FIG. 2.—CAUSTIC POTS BOILING, SHOWING METHOD USED IN HANDLING HOT CAUSTIC INTO DRUMS READY FOR SHIPMENT.

enced in preparing a regenerator whose chemical action should provide for perfect absorption of CO_2 and at the same time maintain a temperature sufficiently low as to cause no discomfort to the wearer either from exterior contact with the apparatus or from hot air provided for respiration.

In the early forms a fluid solution containing caustic potash was used. The oxygen was exhausted from the bottle by the efforts of the wearer. The next improvement was the use of

FIG. 3.—CAUSTIC POT BEING LIFTED BY ELECTRIC CRANE IN PREPARATION TO A THERMIT POUR.

flax or cotton waste, which was saturated with the regenerating compound and the compression of the oxygen into iron tanks. The great danger in both these equipments lay in the wearer's inability to regulate the flow of oxygen and to avoid a cumbersome regenerator of irregular and uncertain capacity.

The first type to merit general recognition outside of Austria had a regenerator for which the filler had to be prepared

at the time the apparatus was to be used, a proceeding which entailed great delay and serious loss of life, since it is a well-recognized fact that such apparatus is of the greatest service only when it is immediately available upon the first advice of a catastrophe involving loss of life from asphyxiation of any kind.

Attention was then directed to the preparation of a regenerator whose absorptive capacity should be constant for a given period, and which could be sealed and delivered in perfect condition at any point, ready for immediate use on breaking the seals.

This having been accomplished, effort was concentrated toward providing the maximum area of absorptive surface in order that less heat should be generated and so that a cooler, hitherto necessary, could be dispensed with.

Various shapes of oxygen bottles were tried, but it is now the practice to use the standard cylindrical type so common in all medical apparatus utilizing oxygen.

The elimination of reducing and by-pass valves and the continued simplification of the apparatus has eventually evolved a complete, light weight, "foolproof" and thoroughly reliable form, known as the Westfalia Rescue Apparatus. This type is largely in use by the United States Bureau of Mines, having recently been furnished for the Rescue Station at Pittsburgh and the new station at McAlester, Okla., and on several of the Mine Rescue Cars now being equipped for use in Wyoming, Missouri, Oklahoma, Arkansas and Pennsylvania.

The Illinois Mine Rescue Station Commission are likewise equipping their new stations and three cars with a number of sets of this type.

Until very recently the helmet was supposed to be a necessity, but the Westfalia mouthpiece type now on the market has proved equally safe and possesses many advantages over the helmet.

Earlier and all other types of helmet depend upon the inflation of pneumatic pads for making a tight fit around the face and head, whereas in the Westfalia apparatus an elastic face washer is provided which fits any inequality or irregularity and enables any person to wear the helmet without the usual difficulties of securing a good fit and renders its continued use a matter of no discomfort. These face washers are also provided with an inflating bulb and pneumatic pad, but the safety of the helmet in no wise depends upon the pneumatic pad, since even if it is punctured or the rubber old and weak, the face washer continually conforms to the head and has no angles or creases. It is also easily removed from the helmet and replaced.

The mouthpiece type referred to may be instantly substituted for the helmet and requires no change of apparatus. The nose clip, whose chief danger lies in the laceration of the nose, or its accidental removal by sneezing, and general discomfort, is also obviated with the Westfalia mouthpiece and in its stead cotton plugs, dipped in vaseline, are inserted in the nostrils and an ordinary guard worn over the nose.

A speaking diaphragm attached to the mouthpiece enables the wearer to carry on conversation without difficulty. The regenerators are also furnished in one-hour, two-hour and three-hour types, so that for practice purposes the smaller ones may be used, while in emergencies the three-hour type provides 50 per cent greater capacity than any other. These regenerators being curved to fit the back, the framework leaving an air space between, and the total thickness being reduced to a minimum, the wearer is enabled to crawl through a smaller space than has heretofore been possible. They are also made interchangeable, thus affording owners of older types of other makes of apparatus all the benefits to be derived from the improved regenerator.

The field in which this apparatus is used is not confined to mines, but is also rapidly extending to chemical works, smelters and in extinguishing fires where dense or dangerous gases, smoke or fumes are encountered.

Not less worthy of consideration is the reviving apparatus which is applied to persons asphyxiated by gas or overcome by smoke or water, and which is so commonly used in hospitals for extreme respiration. In this, also, simplicity has been the aim and the "Dr. Brat" system is supplied in a light portable case ready to be instantly and intelligently applied by any person who can read the indices on the operating lever.

Until very recently such apparatus was operated by clockwork, but the chief objection to this lies in the fact that an unconscious or semi-unconscious person breathes in gasps and with extreme irregularity, and any attempt to force oxygen into or exhaust smoke or gas from the lungs with clockwork regularity must inevitably tend to choke the patient. By eliminating the clockwork attachment a light breathing bag is provided for observation and the inhalations and exhalations of the patient are assisted by a slight movement of the lever, which first exhausts the lungs and then injects oxygen, both of which processes are performed under any desired pressure or vacuum up to 2.5 atmospheres.

All this apparatus is on exhibition at the offices of the Westfalia Engineering Company, 42 Broadway, New York City.

Alundum Refractories.

The development of electrically-heated laboratory apparatus has been very great during the last two years, and to meet this demand the Norton Company, of Worcester, Mass., and Niagara Falls, N. Y., has been making use of the refractory qualities of its abrasive product, alundum, made up into the

FIG. 1.—ELECTRIC FURNACE PARTS OF ALUNDUM.

various shapes required in crucible, muffle and tube furnaces. This has led them into other lines, and now this company is offering a general line of alundum refractories of a high grade, comprising not only the articles for winding with high-resistance wire, but also general utility muffles, crucibles, furnace parts and bricks.

The properties which have made it superior for these pur-

FIG. 2.—ALUNDUM TUBES.

poses are high melting point, high heat conductivity, low coefficient of expansion and resistance to chemical action.

Alundum is fused aluminum oxide and is made by melting and purifying the mineral bauxite in a special electric furnace, which, together with the process of manufacture, has been described before in this journal. It is primarily an abrasive material, but the properties mentioned above make it useful as a refractory. There are several grades for abrasive pur-

poses, but only two of these are used in this work. A white product having less than 1 per cent of impurities is used in all the smaller articles, while a brown material with 6 to 8 per cent of impurities is used in larger shapes and in bricks.

The articles so far turned out are mostly porous, consisting as they do of more or less finely-divided grains, held together by a ceramic bond. This porosity renders them unfit for any work in which a gas-tight chamber is required, but on the other hand is very advantageous in another way, for the porosity can be varied to such a degree that crucibles and dishes may be used for filtering purposes. The Gooch type of crucible works perfectly on all precipitates met with in analytical work. It is a great time saver in the laboratory,
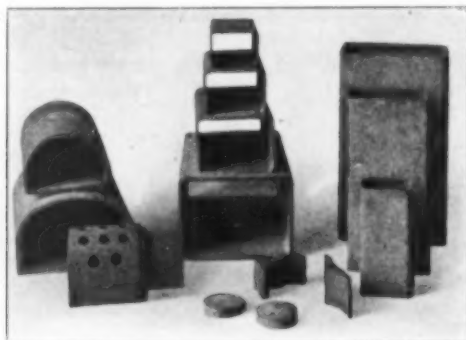

FIG. 3.—ALUNDUM MUFFLERS

as it does away with burning filter papers or preparing asbestos blankets. The crucibles are quite unattacked by aqueous acids or alkalies, so that almost any analysis may be made in them safely.

The mufflers last from four to five times longer than the ordinary fire-clay type, when used in a gas furnace, and when wound with resistance wire are almost the only kind that can be used. The builders of this latter type of furnace use alundum cores exclusively in all shapes and sizes of furnaces.

Combustion boats made of alundum may be used repeatedly in steel-works analysis, as the oxidation products do not stick in the boat or attack it. If other boats are used they may be protected by a layer of carefully-prepared carbon-free alundum grain, which is put up in convenient-sized packages.

Alundum cement may be used for lining crucibles and small furnaces, as it has the same composition and refractoriness as the made-up forms. It is sold, ready for use, except for moistening with water.

The crucibles of denser structure may be used for melting metals but are attacked by slags. The melting point being
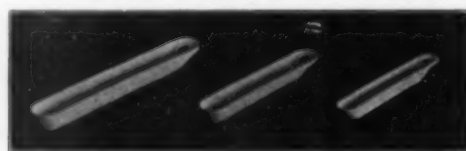

FIG. 4.—ALUNDUM COMBUSTION BOATS

very high, about 1950 deg. C., and also sharp without gradual softening, makes them especially well adapted for melting the metals of the platinum group, and the purity of their composition renders the melt free from contamination.

Bricks have been made experimentally, but the high cost of manufacture and their great weight makes them available only in special cases. For roofs of electric furnaces they are well adapted, on account of high melting point and low coefficient of expansion. Some trials have been made and others are under way to thoroughly test their value for this work. Announcement will be made of the outcome of the

trials when they are completed.

Some attempts at casting alundum articles from the molten state have resulted in partial success. On account of the extreme difficulties in the way, only tubes and small crucibles have been prepared, and these are rather crude in appearance, the hardness of the product making it well-nigh impossible to work them into any smoothness after they are cast.

Fig 1 shows various electric furnace parts made of alundum. The high thermal conductivity has here the advantage that the heat generated in the resistance wire is conducted away so rapidly that overheating and consequent burning out of the resistance is prevented. At the same time the chemical inactivity prevents corrosion of the heating wire. By the use of alundum cement, the element can be completely encased, preventing oxidation and corrosion.

Fig. 2 shows a variety of alundum tubes for high-temperature electric-furnace work.

Fig. 3 shows a variety of alundum muffles for furnaces heated by electricity, gas or gasoline. These alundum muffles last from four to six times as long as the ordinary clay muffles.

Fig. 4 shows alundum combustion boats, which, while adapted to any kind of combustion work, were especially designed for the determination of carbon in iron and steel. The pure alundum of which they are composed does not react with the iron oxide of the sample, and the boats can be used repeatedly.

A large display of the shapes already made will be on exhibition at the Chemists' Club, in connection with Mr. L. E. Saunders' paper at the April meeting of the American Electrochemical Society, and some demonstrations of the advantageous properties will then be arranged. The variety exhibited will show the possibilities of moulding, and special shapes may be made to order, of almost any degree of intricacy.

The articles are on sale at the Worcester, Mass., plant of the Norton Company, and descriptive literature and price lists will be sent on request.

Fused Quartz and Quartz Glass.

By Charles Colne.

From time immemorial quartz has occupied a well-known and useful position in the manufacture of glass. In the shape of white sand or quartz crystals it enters in the proportion of about 60 per cent in the composition of the different qualities of glass, for bottles, windows or hollow ware. Lime, potash and soda are used in order to obtain a fusion at a low temperature, bordering on 1300°, to treat the mass in a refractory furnace heated by coal or gas. Such additions, however, alter the qualities of quartz.

It has been discovered long ago that in melting quartz alone at a temperature above 2000° a transparent body is obtained which is insoluble in acids and is an insulator of a superior quality to common glass. Such a product, sometimes erroneously called quartz glass (because it is not glass, but pure silica), has been manufactured commercially for several years with the oxyhydric blow pipe or in the electric furnace. Before these processes reached a practical point inventors found themselves beset by many difficulties. The methods used were very complicated and it is only since the World's Fair of 1900 that anything like success has been reached, as was shown when the firm of Schott exhibited quartz plates produced by fusion.

Inventors were then restricted to the use of the gas blow pipe as the only means of obtaining the needed temperature. Mr. Shenstone's process was to heat Brazilian quartz to a very high temperature, then throw it into water. Crystals would then divide into small fragments; these were agglomerated

in the shape of rods and fused by the blow pipe into thick thread. These threads were wound up spirally around a large platinum thread and again submitted to fusion, producing small tubes of regular shape. These tubes closed at one end, were drawn out and blown into small balls with which small capsules and bulbs were made.

This method later on was improved by preparing directly small, thick, short tubes in an iridium or zirconium capsule, then drawing and blowing them. The cost price of such articles was very high, as high as $110 per pound. Moreover, these objects had very thin sides, were very frail and of necessity of restricted dimensions. They were, however, very transparent—of a transparency that could not be reached with other processes.

Dufour, Callender and Le Chatelier in their experiments have shown that the fusing point of quartz is very near its ebullition. This explains the difficulty of working the melted mass, or more properly, the pasty mass of quartz which has passed from the crystalline state to the amorphous state. A melted mass of this nature shows a tenacity like that of hot asphalt and work must be carried on rapidly, as when the source of heat has been removed solidifying takes place at once. Such extraordinary viscosity almost prevents the expulsion of bubbles which are formed during fusion. In order to get rid of these bubbles a preliminary baking or fritting of the quartz is necessary. Other efforts have been made to obtain fusion under pressure, but apparently with no practical results.

It is only since 1901 that the first attempts have been made to make glass in the electric furnace. A German firm, Becker & Company, of Berlin, appears to have been among the first to make such trials. Since that time these furnaces have been much used for making quartz glass and the result has been to develop the different methods now in use. The active part of a blow-pipe flame is in fact too restricted to allow large quantities of quartz or quartz glass sand to be treated. As soon as the mass to be treated exceeds a few pounds a mass is obtained without transparency looking like porcelain.

The electric furnace did not give satisfactory results either in the first experiments. Trials made to melt glass sand with an arc furnace resulted in getting ingots of glass as large as a fist with a silvery iridescent surface. To bring such ingots to the shape of a receptacle the resistance furnace had to be brought into play. The product, however, was impure owing to the contact of the quartz with the carbon electrodes and the objects made were covered with a coat of silicate of carbon.

Since that time it has become possible to melt white sand completely in the resistance furnace of Borchers. The quartz blocks obtained are drawn so as to make opaque tubes long enough and free from impurities. This process consists in using a furnace in which in a space left vacant between the terminals is placed a tube of thin carbon perforated like a sieve and surrounded by the sand; this tube is heated by the current passing through it and fuses the quartz. Compressed air is then forced through this tube in order to expand the quartz cylinder which has been formed against the sides of an appropriate mold.

The quartz so melted, owing to the high temperature of the incandescent carbon, passes from the crystalline to the amorphous state. It is capable of standing a very high temperature and has a very high insulating power; but it is opaque and slightly inferior, in resistance to sudden changes of temperature, to quartz glass melted with the Shenstone and the Heræus blow pipes. However, the latter process cannot make large pieces fit for industrial uses.

A German company has succeeded in producing transparent quartz glass by the following process in the electric furnace: The sand of the glass maker is introduced into a carbon cylinder, used as a crucible, in the center of which is placed a rod of carbon heated by the electric current at the same time as the outside cylinder. Starting with glass sand, of ordinary

quartz, a complete fusion is reached, which, when renewed several times, will produce a transparent mass. To work the latter with a view of getting small objects for laboratory use this can be done either in an electric muffle or with the oxyhydric blow pipe.

As the fusion of quartz and its transformation into the amorphous state require much heat these two successive operations produce objects more rapidly and more economically; the blow pipe serving only for fining and working the already melted quartz in the shape of tubes. Large pieces are blown in a special manner. Instead of using compressed air or steam, which requires a preliminary preparation, or the introduction of the dose in the quartz bar, which is a difficult operation, owing to the rapid solidifying of the mass, there is introduced in the quartz block by the opening left by the central electrode a moistened body which is transformed into steam— some green wood, for instance, or a substance such as marble, which at the high temperature to which it is subjected decomposes and liberates a gas. During that time the ends of the block are held by pincers. The liberated gases force the quartz against the sides of the molds having the desired shape. The mass when solidified is withdrawn from the mold and the objects are then cut to the desired dimensions with diamonds or by fragments of carborundum mounted on disks of copper or zinc. They are then polished.

To strengthen the objects obtained the tubes can also be blown into metallic woven fabrics. It is with such a process that large capsules of 120 in. are obtained for evaporating, and tubes more than 40 in. long and 10 in. in diameter for use as receptacles for acids. The product thus obtained can be substituted for china and stoneware.

The properties of quartz glass have been investigated by sundry experimenters, especially by Le Chatelier, Shenstone and Gaurties; all have shown how raw quartz not melted is sensitive to variations of temperature; when heated suddenly it breaks in a number of fragments. Fused quartz, on the contrary, which has passed from the crystalline to the amorphous state, resists quite well such changes, especially in a thin shape. Its coefficient of expansion is about 0.0000007 per degree Centigrade, much less than that of platinum. It is interesting to note that the expansion of rods of quartz is quite regular up to 1000° C., but ceases at 1200° C., and at higher temperatures a contraction takes place. The softening point is near 1700° C., the fusion point 2100° C., and at 2200° C. exaporation starts.[1] Its specific weight varies from 2.1 to 2.2.

Quartz is an excellent electric insulator, plates of 1.5 mm to 2 mm thick cannot be pierced except at a tension near 35,000 volts. For a thickness of 7 mm more than 70,000 volts are required.

Being insoluble in acids it makes it applicable to many purposes. It is, however, attacked violently by hydrofluoric acid and slightly by hot phosphoric acid. It does not resist either alkalies. Therefore, laboratory apparatus of quartz glass are sometimes coated with a resisting varnish or a coating of precious metals. The "spray" process for galvanizing, invented by Mr. Schoop (this journal, Vol. VIII, page 404), can be used for such a purpose with economy.

Quartz glass is very translucid for rays of short wavelength. Its great permeability for ultra-violet rays causes it to be used in phototherapy and in the production of ozone for sterilizing water and milk.

Applications of quartz glass are now very numerous and everything points to further extensions. Its great resistance to sudden changes of temperature renders it very precious in chemical laboratories for obtaining capsules and crucibles for making thermometers in which the displacement of zero is nil, etc. For lamp glasses, for globes, for lighting by incandescence, for supports for mantels, for tubes for levels and steam boilers. Mercury-vapor lamps are also made with bulbs of quartz glass.

[1] Others give the melting point as between 1700 and 1800° C and state that softening occurs at 1500° C.—ED.

Non-transparent quartz can be shaped into vases of large dimensions and takes the place of stoneware with advantage in making pipes used to carry acids, lining for refrigerators and heaters. It also can take the place of porcelain or platinum for making concentration apparatus more durable and cheaper.

Quartz glass is now made by three principal firms, in England by the Thermal Syndicate, Limited, and two in Germany, the Heraeus Campany and the Deutsche Quartz Gesellschaft.

At the factory of the latter objects of large dimensions are obtained by means of a resistance furnace, made of a hollow carbon cylinder of about 200 mm diameter with a central carbon rod. The space left vacant between carbons is filled with white sand and an electric current is passed through the carbons, which are raised to the temperature of 2500°. Each furnace can make an ingot of about 50 kil. The ingot is taken out with pincers; in the hollow part is introduced a gasifying body to do the molding, as described before. The fusion-room contains two large transformers from which 18 furnaces can draw power. Around a third room are distributed the finishing rooms, such as for the treatment with sand blast, grinding with diamonds or carborundum, blowing with the blow pipe, repairing, etc.

Of late years the industry of quartz glass has increased considerably owing to new processes using the electric furnaces. The cost price of manufacture has decreased materially. Although it is yet too high to allow the sale of the objects for the same price as those of common glass of the best quality the qualities of quartz glass give it a preference in a great number of applications where its use is now a necessity.

Large Bronze Casting

The accompanying illustration shows an interesting and rather exceptionally large bronze drum casting. The drum is 12 feet long and 5 feet in diameter, and is used as the drying surface in a large vacuum rotary drum dryer. Such drums are generally made of dense air furnace iron, but in this case it was necessary to use a high quality bronze drum due to the fact that the vegetable extract to be dried on the drum would become discolored if it came in contact with the iron.

BRONZE CASTING

The mold for this casting was swept up in dray sand, the core being swept in loam. When the casting was poured the mold was in a vertical position, thus accounting for the very clean surface free from any blow holes. It required 16,000 pounds of metal to pour the casting and on account of this large quaitity it was necessary to melt the metal in a 48-inch cupola. To melt bronze in a cupola is unusual, but the Buffalo Foundry & Machine Company, who made the casting in question, has been very successful in following this practice where large quanties of metal are required.

An Experimental Arc Furnace for Fine Ore Reduction.

An exhibition of the Reid electric smelting process was given on March 9 at the workshops of the Cobalt Reduction and Refining Company in Newark, N. J. Mr. James H. Reid who some years ago was interested in the promotion of a carbon cell, has developed during the last years an arc-furnace process for the treatment of fine ores, as follows:

The ore fines are fed in a continuous stream by gravity through an electric arc. Within the arc they are reduced (as there is no reducing agent employed, as was exactly stated, the ore must have such a composition or must itself contain such elements as to make reduction possible). The particles of hot reduced metal together with the gangue drop into a box with running water. On the sudden contact with the water the particles of gangue explode and are carried away in the stream of water, while the reduced metal or alloy collects on the bottom of the box. The volatile matter in the ore, when subjected to the heat of the arc is evaporated and the vapors are sucked off from the furnace by a fan and recovered in condensers.

This process was exhibited with an experimental furnace, the capacity of which was given as 1 ton of ore for 24 hours. Exact data of cost, if working on a large scale, are not yet available. The purely electrical and mechanical part of the experimental furnace appeared to work quite nicely. The electrodes between which the arc was produced were of steel. But on a large scale when treating nickel-cobalt ore, it is proposed to use nickel-cobalt electrodes, part of the reduced alloy being used for casting the electrodes. Mr. Reid estimates that the electrode consumption per ton of alloy produced will be 660 pounds of nickel-cobalt electrodes.

The reduced alloy, which collects on the bottom of the water box, is to be treated in a separating kettle, which was shown, but not exhibited in operation. It is provided with electrodes, simply for melting the alloy. Further it is arranged so as to be rotated. The object of this is to separate the constituents of the alloy (perhaps after making a suitable addition) by specific gravity into tops and bottoms.

The company intends to build a larger plant embodying these ideas, near Cobalt, Canada.

Electric Furnace Exhibit.

The high development of the laboratory and smaller industrial electric furnace is well shown at the permanent exhibition room of the Hoskins Manufacturing Company in Chicago.

The large muffle furnace for the heat-treatment of high-speed steels, shown in the very center of the photograph, is always of especial interest to visitors, due to the remarkable evenness of the "electric heat" it displays. A temperature of 2300° Fahr. may be produced and this may be regulated to a very fine point

ELECTRIC FURNACE EXHIBIT

by a simple turning of hand-screws in the power circuit. Close to this a crucible furnace, operating on the same carbon-resistance principle, is shown, capable of melting platinum.

For combustion determinations of carbon in steels the new electric tube furnace, heated by large cross-section metallic elements, is exhibited. This is seen between the muffle and crucible furnaces on the table at the right.

The exact temperature of each furnace operated is clearly shown by means of a full pyrometer installation.

A Novel Laboratory Electric Furnace with Replaceable Heating Units.

We had recently an opportunity to witness a demonstration of an interesting new type of electric laboratory furnace at the workshops of the manufacturers, the Multiple Unit Electric Company, with offices at 47 Maiden Lane, New York City.

This type of furnace is built under patents of Mr. M. M. Kohn. Its chief feature is the replaceability of the electric heating units so that anyone which might burn out can almost instantly be replaced by a new one, held in reserve. The repairs

TYPE CR CRUCIBLE FURNACE

of the furnace are thus made exceedingly simple and rapid.

The housing of the furnace is built of a number of sections of a special clay, formed to meet the requirements of each particular case. They are held together by a special cement which will not crack as a result of heating and cooling. This housing which also carries the necessary electrical connections, after being assembled is placed in a metal case, together with the necessary heat resisting material, and is then sealed in permanently, as it is never necessary to remove or change it in any way, unless the furnace housing has been mechanically damaged.

In this housing certain peculiarly shaped openings are molded, into which the replaceable heating units fit, the openings being shaped according to the nature of the furnace, viz.: circular

TYPE CO COMBUSTION FURNACE

for the crucible and combustion types; and rectangular for the muffle type. The removable units which are replaced in case of a burn-out, carry the necessary heating medium, which may be wire or other material suitable for the purpose. The number of units required, depends entirely on the type of furnace, some requiring two, others four, or more.

In case of a burn-out, all that is necessary is to remove the unit which is burnt out and slide in another one, which can be

done by anyone, without any technical knowledge. Units can be replaced, when the furnace is red hot, in less than ten minutes.

These units are made of special clays and other refractory materials in various forms and sizes to meet the requirements of each case. They are made in a number of sections or pieces, each of which is complete in itself and are assembled on rods of special material, which act not only to tie or hold them together, but also as the electrical conductors to carry the current from the housing to the heating medium in which the units are wound. Looking at the front of a unit a number of undercut open slotted grooves are seen, into which the heating medium (wire, etc.), is placed, which while holding it firmly in place still allows for expansion of the medium, while another very important feature of this special groove is the open slot, which allows for the full heat of the medium being utilized in the furnace chamber.

On account of the method of building up the furnace housing of sections it is easy to build the furnace in any size or shape as desired. For instance, a 4-inch furnace may be easily changed into a 5-inch furnace by inserting proper distance pieces.

Further by the method of connecting the heating units it is possible to get a uniform heat within the whole furnace, or to get higher or lower temperatures at different places, according to the requirements of the case. This latter condition must be fulfilled, for instance, in electric furnaces for the automatic heat treatment of blades for safety razors. While the blades pass through the furnace they are subjected to different tem-
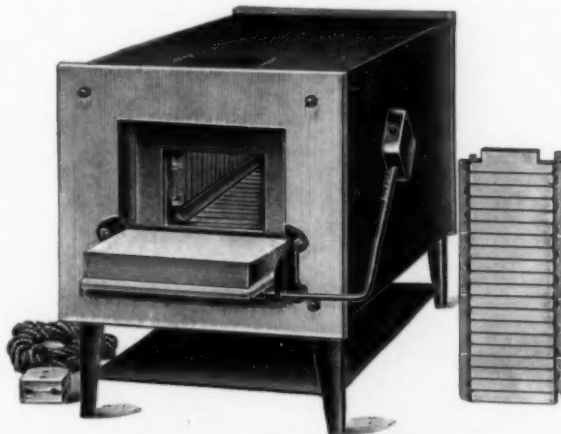
TYPE MU MUFFLE FURNACE

peratures according to the requirements of the heat treatment. Quite a number of Kohn furnaces are in successful commercial use just for this purpose.

Another feature of the Kohn furnace is that it is built for direct operation on 110- or 220-volt mains without necessitating the use of a transformer. Any muffle or combustion furnace can be used on either 110 or 220 volts by simply shifting a plug from one set of contacts to another, according to the voltage that is to be used.

Any of the Kohn furnaces may also be equipped with an additional two-heat switch, by means of which it is possible to obtain ¼ heat or full heat, and also with special three-heat switches by means of which 1/3, 2/3 or full heat is obtained, both without the use of a rheostat or external resistance, and with absolute uniformity of temperature.

The safe maximum working temperature of the Kohn furnace is from 1750° to 1850° F. But in emergency cases they will stand temperatures up to 1900° F. for a short time.

The adjoining illustrations show the standard types of the Kohn furnace, the type CR crucible furnace, the type CO combustion furnace and the type MU muffle furnace. In each case a heating unit is illustrated on the side of the furnace, to show its construction.

Digest of Electrochemical U. S. Patents.

Prior to 1903.

Arranged according to subject matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Ore-Treatment (Continued).

286,208, Oct. 9, 1883, Leon Letrange, of Paris, France.

Zinc. Calcines blende to zinc sulphate and passes the fumes over calamine undergoing calcination, partially converting it into a sulphate. Unsulphated zinc oxide is dissolved by dilute sulphuric acid in vessels of masonry lined with bitumen. The several vessels are successively charged with mineral and acid, drained and refilled. The zinc is precipitated from the acid solution in electrolytic cells of wood lined with glass or lead, the anodes being plates of carbon and the cathodes thin plates of zinc, copper or polished brass from which the deposit is stripped. The liberated sulphuric acid overflows through outlets at the top of the cells, the level of the bath being maintained by the introduction of fresh solution.

291,670, Jan. 8, 1884, Michel Body, of Liege, Belgium.

Gold and silver. The ore is ground fine and either treated in heaps with a ferric-salt solution or mixed with ferric salts and roasted. It is then placed in an electrolytic amalgamator, consisting of a revoluble horizontal cast-iron drum, serving as cathode and containing a number of cast-iron balls. The anodes are plates of compressed coke or graphite, suspended from a stationary, hollow, perforated, insulated shaft passing through stuffing boxes in the ends of the drum. The elec-shaft.

A steam pipe also does enter the electrolyte. The silver deposits on the drum and balls and is absorbed by mercury subsequently introduced into the drum. The ferric salts are simultaneously converted into the ferrous form.

300,950, June 24, 1884, Henry Benner Cassel, of New York, N. Y.

Dissolves metals, especially gold, by electrolytic chlorine. The cell is a tank containing a semi-annular sheet cathode. The tank receives the lower half of a rotary horizontal drum, containing a series of carbon rod or plate electrodes, arranged peripherally. The ends of the anodes extend through the heads of the drum and are connected by copper wires to a copper rod on one axle, making contact with a fixed copper spiral. The heads, or the cylindrical or polygonal body of the drum, may be of porous clay. Or the body of the drum may be omitted and replaced by a diaphragm secured in the stationary tank.

The ore which is to be treated is placed in the drum or anode compartment with a sodium-chloride solution, and is agitated by the anodes as the drum rotates, the metal being dissolved by the liberated chlorine. It is stated that the dissolved metal is not deposited from the cathode.

300,951, June 24, 1884, Henry Benner Cassel, of New York, N. Y.

Gold. Pyritic and other refractory auriferous ores are electrically dissolved in a sodium-chloride solution. Lime, or equivalent, is added to neutralize the hydrochloric and hypochlorous acids formed and prevent their converting iron in the ore into a proto-salt which would precipitate the gold from its chloride solution.

Or a solution may be employed which will yield a base capable of neutralizing the acids.

317,245, May 5, 1885, Edward P. Thompson, of Elizabeth, N. J., assignor of three-fourths to E. P. Roberts and G. H. Pierce, both of Cheyenne, Wyom.

Gold. Dissolves gold by placing the ore in a tank of lead lined with paraffine, pitch or asphaltum, filled with water and introducing a stream of chlorine at the bottom. The resulting gold-chloride solution is electrolyzed in a cell having anodes and cathode of carbon. Some gold ore may also be placed in this cell to absorb the chlorine freed therein. A number of cathodes coated with gold are packed with fine charcoal in a crucible and heated until the gold melts and runs into a button at the bottom. The chlorine for treating the ore may be produced in an electrolytic cell having an anode of carbon and a cathode consisting of a metal pipe through which steam is introduced into the solution of sodium chloride, acidulated with a few drops of hydrochloric acid. Or a lead-chloride solution may be electrolyzed between a carbon anode and a lead-plate cathode.

BOOK REVIEWS.

Electrische Öfen in der Eisenindustrie. By Dipl-Ing. **W. Rodenhauser** und Betriebsdirektor **I. Schoenawa.** Octavo, 326 pages, 127 illustrations. Price in paper, marks 13.50; cloth, marks 15. (Retail price in New York: $4.50.) Leipzig, 1911; Oscar Leiner.

Electric furnace literature contains many erroneous statements and claims, which contradict the fundamental principles of electrotechnology. The authors have placed before themselves the task of giving complete and accurate information on the electric furnaces used in the iron and steel industry and their operations.

It is not probable that there are in Europe many more metallurgical engineers better qualified to accomplish this task than the designer of the Roechling-Rodenhauser induction furnace and his chief works manager, the above named authors. That two such busy technologists would take the time to write such a treatise for the benefit of the industry and the enlightenment of their colleagues and competitors proves that they are the opposite to narrow technicians—proves that they are broadminded benefactors of science and industry.

Congratulations are due them in the successful manner in which they have executed their task. To those interested in electric furnaces it may seem that the authors have exaggerated the relative advantages of the induction furnace; but a sober second thought on this question will suggest the possibility that induction furnaces are perhaps better suited for certain metallurgical operations than electrode furnaces, and that their star may be again in the ascendant.

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Herstellung Kolloider Lösungen anorganischer Stoffe. Ein Hand und Hilfsbuch für die Chemie und Industrie der Kolloide. von Dr. **The Svedberg**, Privatdozent an der Universität Upsala. Octavo, 507 pages, 60 illus. Dresden: Theodor Steinkopff.

Kapillarchemie. Eine Darstellung der Chemie der Kolloide und verwandter Gebiete. von Dr. **Herbert Freundlich**, Privatdozent un der Universität Leipzig. Octova, 591 pages, 75 illus. Price, 17.50 marks. Leipzig: Akademische Verlagsgesellschaft m.B.H.

These books represent one of the most rapidly advancing branches of theoretical and applied chemistry; a field practically on the border line between physics and chemistry. The extent to which colloidal chemistry has been proved to enter into the chemistry of every-day life and the vast field opened up for experiment, observation and development of satisfactory theory should, and undoubtedly will, attract many earnest chemical students. Dr. Svedberg's book deals principally with the processes of producing colloids by the methods of condensation and of dispersion, while Dr. Freundlich's deals principally with surface tension, separating surfaces and the detailed properties of suspension colloids, emulsion colloids and gels. There is a wealth of interesting and useful information in these two works.